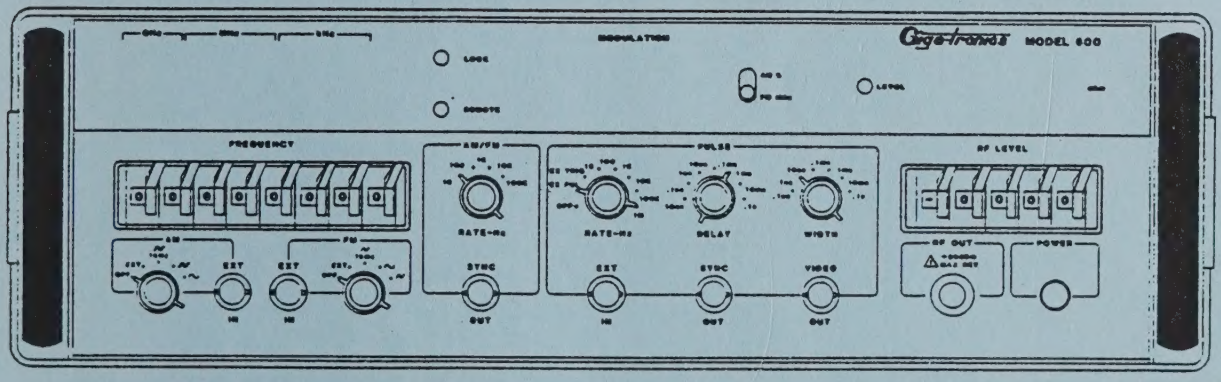
Giga-tronics
INCORPORATED

OPERATION [redacted] MANUAL

SERIES 600

SYNTHESIZED MICROWAVE

SIGNAL GENERATOR



This manual applies to all Series 600 instruments. For information regarding instrument configuration and options, see page iii.

Shipping Assembly Part Number: see page iii.

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SECTION ONE

OPERATING INFORMATION

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1.0 THE FRONT PANEL

The instrument's major controls and connections are located on the front panel and are illustrated in Figure 1.1; the various functional sections of the front panel are described below.

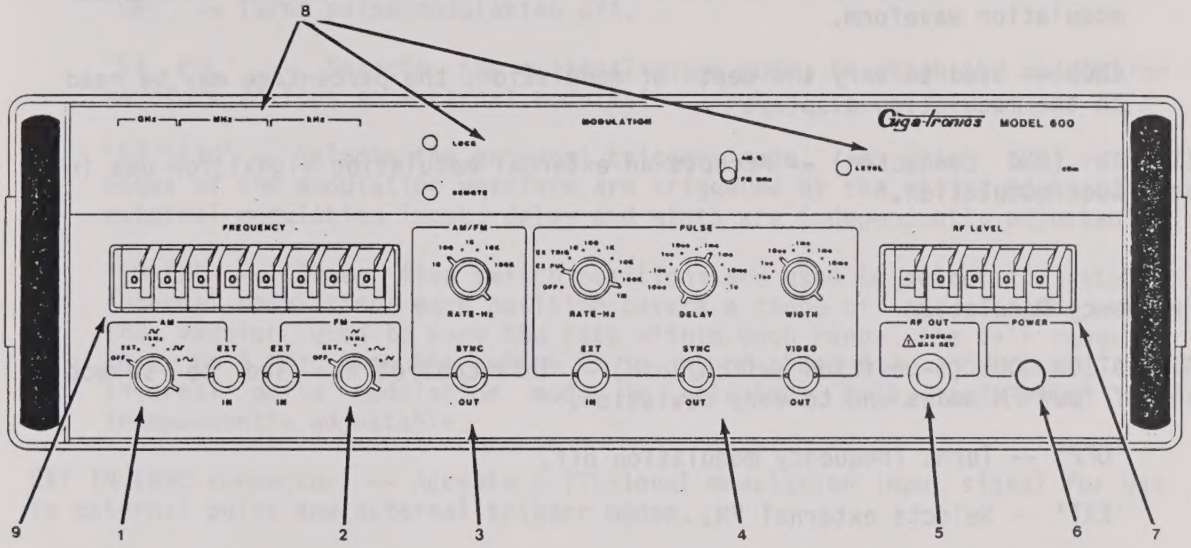


Figure 1.1: Series 600 Front Panel

1. Amplitude Modulation
2. Frequency Modulation
3. AM/FM Rate
4. Pulse Modulation
5. RF Output
6. Line Power
7. RF Level Setting
8. Displays
9. Frequency Setting

Amplitude Modulation

MODULATION MODE (5-position switch/knob) -- This control is used to select any of four AM modes and to vary modulation depth.

'OFF' -- Turns amplitude modulation off.

'EXT' -- Selects external AM.

'1 kHz' -- Selects internal AM with a fixed 1 kHz square modulation waveform.

'⎍' -- Selects internal AM with a variable-rate square modulation waveform.

'∿' -- Selects internal AM with a variable-rate sinusoidal modulation waveform.

KNOB -- Used to vary the depth of modulation; the percentage may be read on the modulation display.

EXT IN (BNC connector) -- Accepts an external modulation signal for use in amplitude modulation.

Frequency Modulation

MODULATION MODE (5-position switch/knob) -- This control is used to select any of four FM modes and to vary deviation.

'OFF' -- Turns frequency modulation off.

'EXT' -- Selects external FM.

'1 kHz' -- Selects internal FM with a fixed 1 kHz triangular modulation waveform.

'∿' -- Selects internal FM with a variable-rate sinusoidal modulation waveform.

'⩘' -- Selects internal FM with a variable-rate triangular modulation waveform.

KNOB -- Used to vary the deviation; the amount of deviation in MHz may be read on the modulation display.

EXT IN (BNC connector) -- Accepts an external modulation signal for use in frequency modulation.

AM/FM

RATE (4-position switch/vernier) -- This control is used to select the modulation rate for internal AM or internal FM. Each of the four positions covers a range of one decade, with the vernier used to vary the frequency within each range; the full range is 10 Hz to 100 kHz.

SYNC OUT (BNC connector) -- Provides a TTL-level square wave at the frequency selected by the AM/FM rate control, for use in synchronizing auxiliary devices to the internal AM or internal FM modulation waveform.

Pulse Modulation

RATE (8-position switch/vernier) -- This control is used to select the pulse modulation mode, as well as to select the modulation rate for internal pulse modulation.

'OFF' -- Turns pulse modulation off.

'EX PUL' -- Selects the external pulse mode, in which the modulation waveform follows an external modulation input.

'EX TRIG' -- Selects the external trigger mode, in which the rising edges of the modulation waveform are triggered by the rising edges of an external modulation input; delay and width are independently adjustable.

'10-1M' -- These five switch positions are used to select the rate of internal modulation; each position covers a range of one decade, with the vernier used to vary the rate within each range. The full range is 10 Hz to 1 MHz. When the switch is in any of these five positions, the internal pulse modulation mode is selected. Delay and width are independently adjustable.

EXT IN (BNC connector) -- Accepts a TTL-level modulation input signal for use in external pulse and external trigger modes.

DELAY (7-position switch/vernier) -- This control is used, in the internal pulse mode and in the external trigger mode, to vary the delay between the internal or external trigger, available at the SYNC output, and the modulation waveform, available at the VIDEO output. (During operation in the external pulse mode, the internal delay generator is disabled.) Each of the seven positions covers a range of one decade, with the vernier used to vary the delay within each range. The full range is 10 nanoseconds to 100 milliseconds.

SYNC OUT (BNC connector) -- Provides TTL-level high pulses coincident with the rising edges of the internally generated or externally applied modulation waveform. The pulses have a fixed width of approximately 50 nanoseconds and are intended for use in synchronizing auxiliary devices. This output does not reflect pulse delay, and is disabled during operation in the external pulse mode.

WIDTH (6-position switch/vernier) -- This control is used to vary the width of the modulation pulses. Each position covers a range of one decade, with the vernier used to vary the rate within each range. The full range is 50 nanoseconds to 100 milliseconds. During operation in the external pulse mode, the internal pulse-width generator is disabled.

VIDEO OUT (BNC connector) -- Provides a TTL-level waveform which follows the pulse modulation waveform. This output reflects pulse delay and is intended for use in synchronizing auxiliary devices.

RF Output

RF OUT (type N connector) -- Provides the RF output over the entire frequency range of the instrument.

Line Power

POWER (pushbutton) -- Used to switch the instrument's power supply on and off; when the button is in the "off" position the transformer primary is disconnected from the AC source.

RF Level Setting

RF LEVEL (leverwheel switches) -- These switches are used to set the RF output level over a range of -110 to +10 dBm in increments of 0.1 dB. The level selection may be read on the RF level display.

Displays

RF LEVEL READOUT (fluorescent display) -- This 5-digit display is used to indicate the RF output level selected.

LEVEL (LED) -- This indicator lights when the instrument is leveled.

MODULATION READOUT (fluorescent display) -- This 4-digit display is used to indicate modulation depth in percent (AM mode) and to indicate deviation in MHz (FM mode).

AM/FM (switch) -- This lever switch is used to select the modulation display mode (AM depth or FM deviation).

LOCK (LED) -- This indicator lights when the RF output is phase-locked to the internal or external master reference.

REMOTE (LED) -- This indicator lights when the instrument is under remote control, via the IEEE-488 interface.

FREQUENCY READOUT (fluorescent display) -- This 8-digit display is used to indicate the selected RF output frequency.

Frequency Setting

FREQUENCY (leverwheel switches) -- These switches are used to select the frequency of the RF output in increments of 1kHz.

1.1 THE REAR PANEL

The rear panel houses input and output connectors used to interface the instrument with other devices. The different functional sections are illustrated in Figure 1.2 and described below.

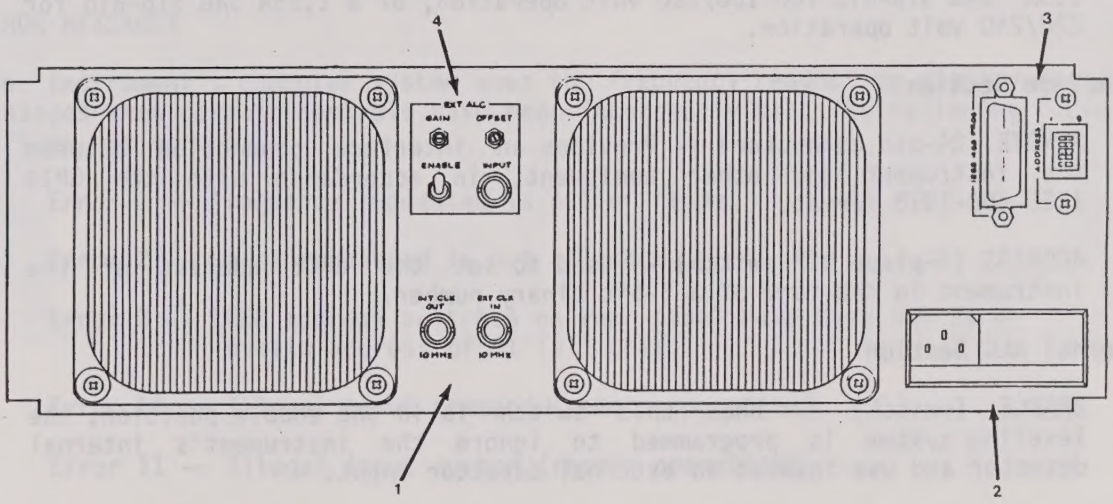


Figure 1.2: Series 600 Rear Panel

1. Master Reference Section
2. Line Power & Fuse Section
3. Interface Section
4. External ALC Section

Master Reference Section

INT CLK OUT, 10 MHz (BNC connector) -- Provides a sample of the 10 MHz internal reference frequency, at 2 Vpp into 50 ohms.

EXT CLK IN, 10 MHz (BNC connector) -- Accepts an external 10 MHz reference input at 1 Vpp, which is automatically substituted for the internal reference frequency.

Line Power and Fuse Section

POWER INPUT (AC plug) -- A 3-terminal polarized connector with the safety ground wired to the chassis.

LINE SELECTION (PC board) -- This card can be oriented four ways to select four different line voltages: 100, 120, 220 and 240 volts.

FUSE HOLDER -- This socket retains the power fuse, which should be a 2.5A 3AG Slo-Blo for 100/120 volt operation, or a 1.25A 3AG Slo-Blo for 220/240 volt operation.

Interface Section

REMOTE (24-pin connector) -- Provides an interface connection between the instrument and other equipment, in accordance with the GPIB IEEE-488-1978 format.

ADDRESS (5-place DIP switch) -- Used to set the GPIB address of the instrument in the form of a 5-bit binary number.

External ALC Section

ENABLE (switch) -- When this switch is in the enable position, the leveling system is programmed to ignore the instrument's internal detector and use instead an external detector input.

INPUT (BNC connector) -- Accepts an input signal from an external detector.

GAIN (potentiometer) -- This screwdriver adjustment is used to calibrate the instrument's leveling system to match the slope of an external detector's transfer curve.

OFFSET (potentiometer) -- This screwdriver adjustment is used to calibrate the instrument's leveling system to match the intercept point of an external detector's transfer curve.

1.2 Front Panel Operation

The following part of section one provides step by step operating procedures for common functional setups.

The basic function of series 600 instruments is to synthesize microwave signals within a given frequency range. Controls are provided to allow selection of frequency, output level, and modulation mode.

ERROR MESSAGES

The instrument's computer system uses the frequency readout to display error messages when certain controls have been incorrectly set. The following table defines the errors:

Error 1 -- Frequency requested is out of range.

Error 2 -- Level requested is out of range.

Error 3 -- IEEE address switches on rear panel have been set to an invalid address of 31 (all ones).

Error 10 -- Illegal input command (remote operation).

Error 11 -- Illegal input number (remote operation).

Setting Output Frequency and Level (No Modulation)

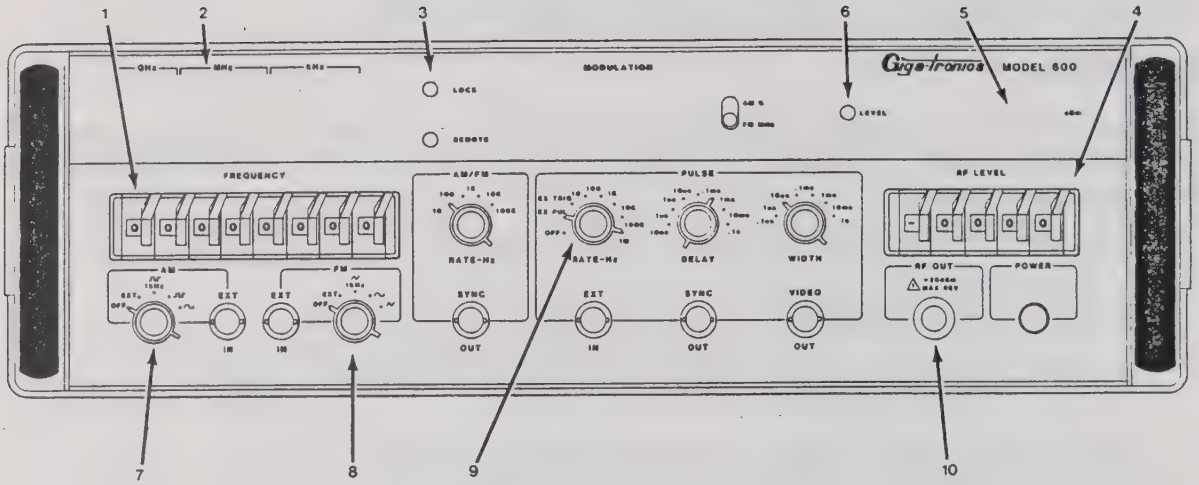


Figure 1.3: Frequency and level settings.

1. Select frequency (leverwheel switches)
2. Read selected frequency on display
3. Verify 'LOCK' indicator is lit
4. Select RF level (leverwheel switches)
5. Read selected level on display
6. Verify 'LEVEL' indicator is lit
7. AM off
8. FM off
9. PM off
10. RF output is available at 'RF OUT' connector

Amplitude-Modulating the RF Output: External AM

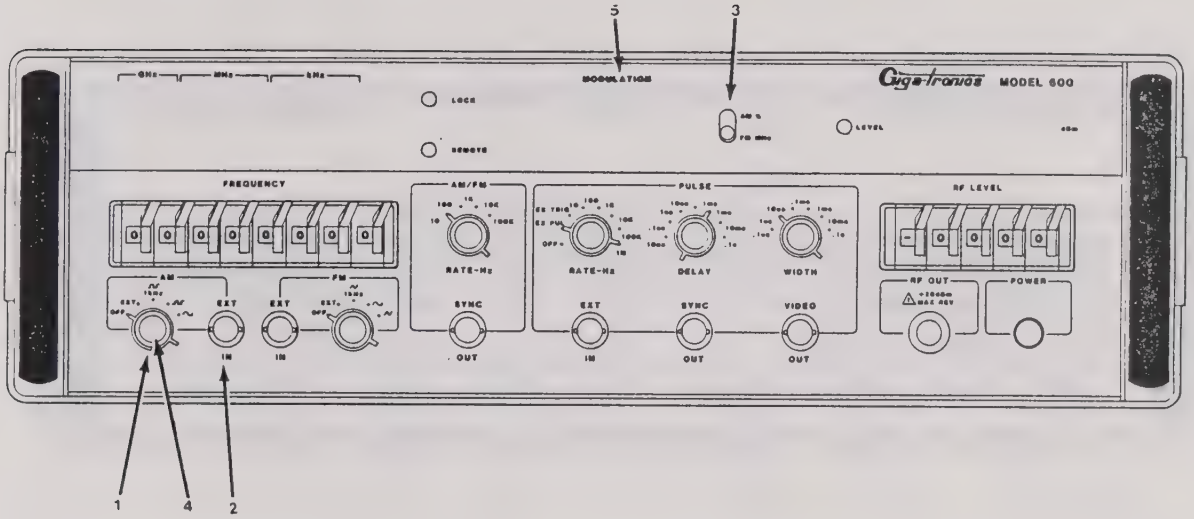


Figure 1.4: External AM

1. Select 'EXT'
2. Apply external modulation signal at 'EXT IN' connector
3. Select 'AM%' (modulation display mode)
4. Adjust modulation depth
5. Modulation depth is displayed on modulation readout

NOTE: If desired, operation in the AM mode can be simultaneous with operation in the other modulation modes.

Amplitude-Modulating the Output: Internal AM

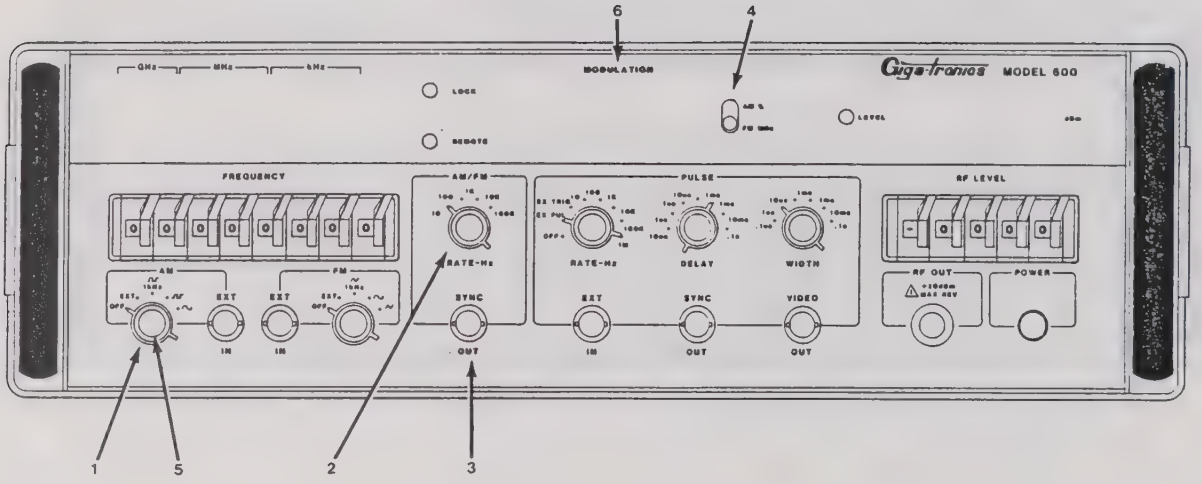


Figure 1.5: Internal AM

1. Select internal AM mode: fixed 1 kHz square, variable square, or variable sine

2. Select rate (variable-rate modes only)

3. Modulation sync-signal is available at 'SYNC OUT' connector

4. Select "AM%"

5. Adjust modulation depth

6. Modulation depth is displayed on modulation readout

NOTE: If desired, operation in the AM mode can be simultaneous with operation in the other modulation modes.

Frequency-Modulating the Output: External FM

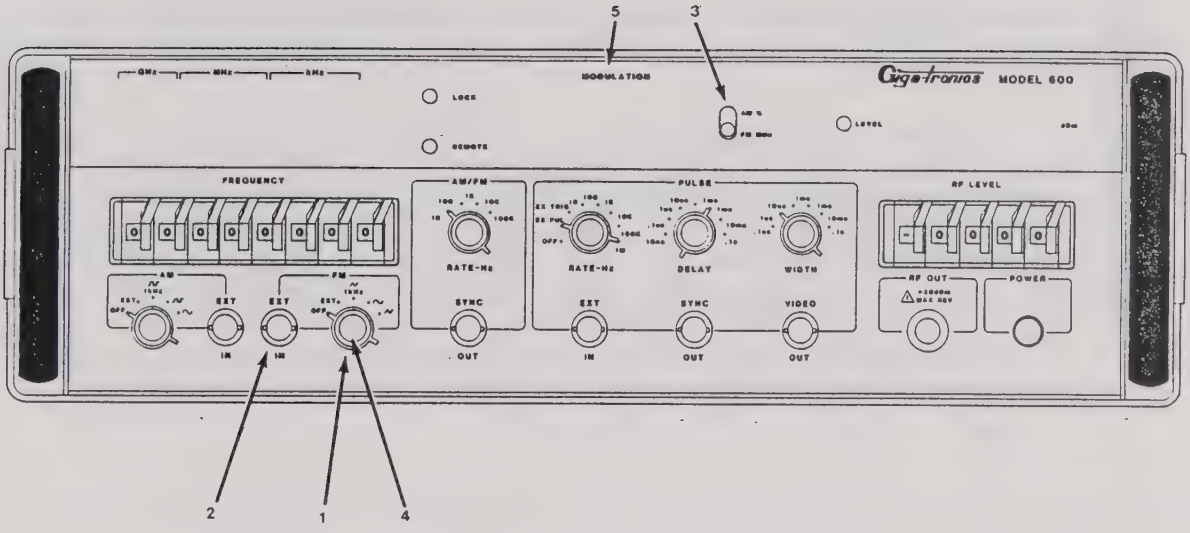


Figure 1.6: External FM

1. Select 'EXT'
2. Apply external modulation signal at 'EXT IN' connector
3. Select 'FM MHz' (modulation display mode)
4. Adjust deviation
5. Deviation is displayed on modulation readout

NOTE: If desired, operation in the FM mode can be simultanteous with operation in the other modulation modes.

Frequency-Modulating the Output: Internal FM

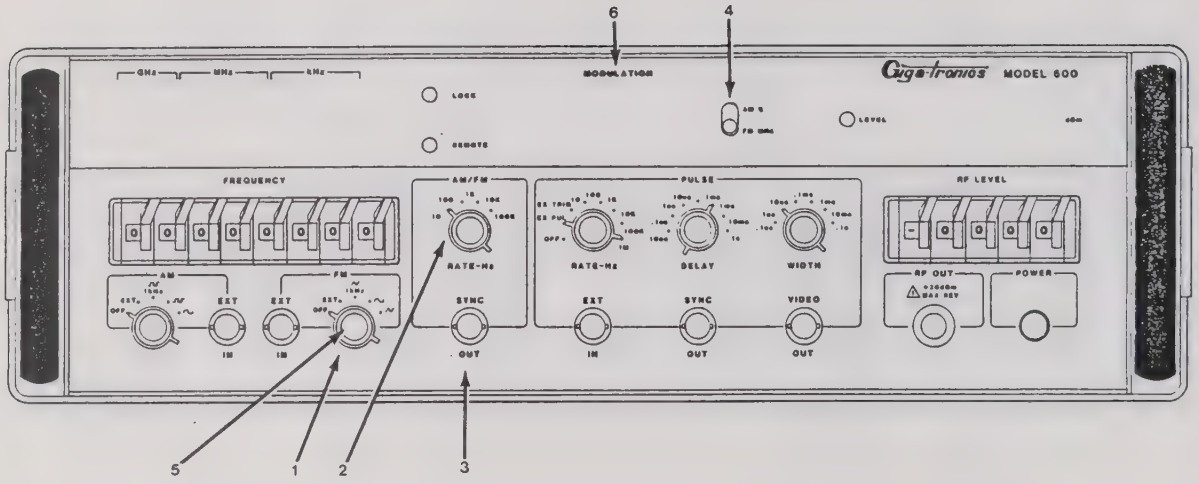


Figure 1.7: Internal FM

1. Select internal FM mode: fixed 1 kHz triangle, variable sine, or variable triangle

2. Select rate (variable-rate modes only)

3. Modulation sync-signal is available at 'SYNC OUT' connector

4. Select 'FM MHz'

5. Adjust deviation

6. Deviation is displayed on modulation readout

NOTE: If desired, operation in the FM mode can be simultaneous with operation in the other modulation modes.

Pulse-Modulating the Output: External Pulse Mode

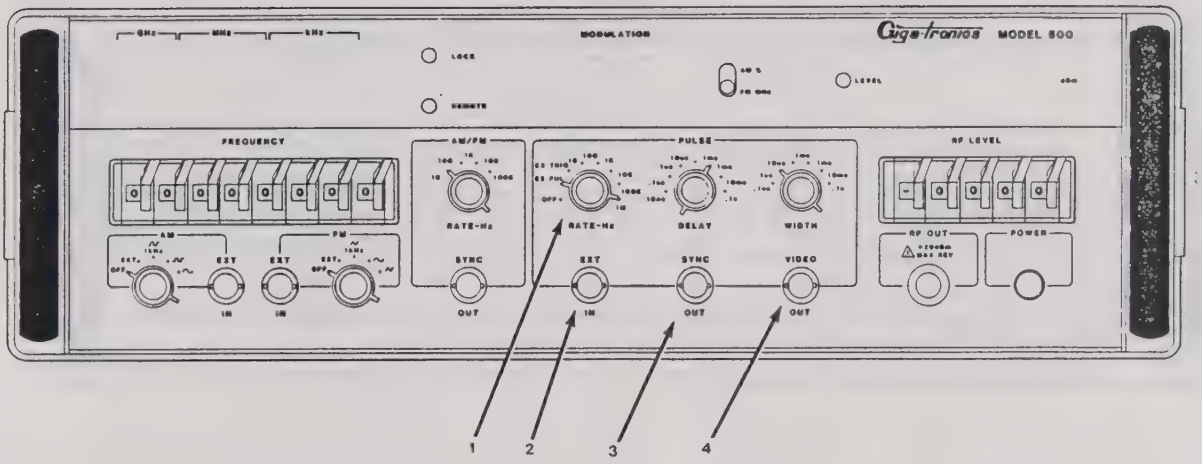


Figure 1.8: External pulse mode

1. Select 'EX PUL'
2. Apply external modulation signal at 'EXT IN' connector
3. Modulation sync pulses are available at 'SYNC OUT' connector
4. Modulation waveform is available at 'VIDEO OUT' connector

NOTE: If desired, operation in pulse modulation mode can be simultaneous with operation in the other modulation modes.

Pulse-Modulating the Output: External Trigger Mode

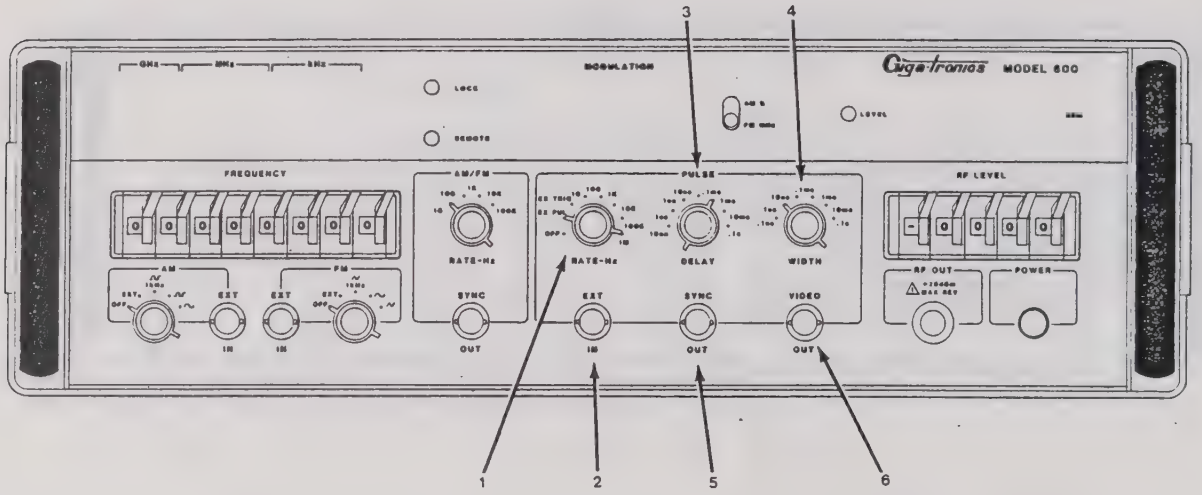


Figure 1.9: External trigger mode

1. Select 'EX TRIG'
2. Apply external modulation waveform at 'EXT IN' connector
3. Adjust pulse delay
4. Adjust pulse width
5. Modulation sync pulses are available at 'SYNC OUT' connector
6. Modulation waveform is available at 'VIDEO OUT' connector

NOTE: If desired, operation in pulse mode can be simultaneous with operation in the other modulation modes.

Pulse-Modulating the Output: Internal Pulse Mode

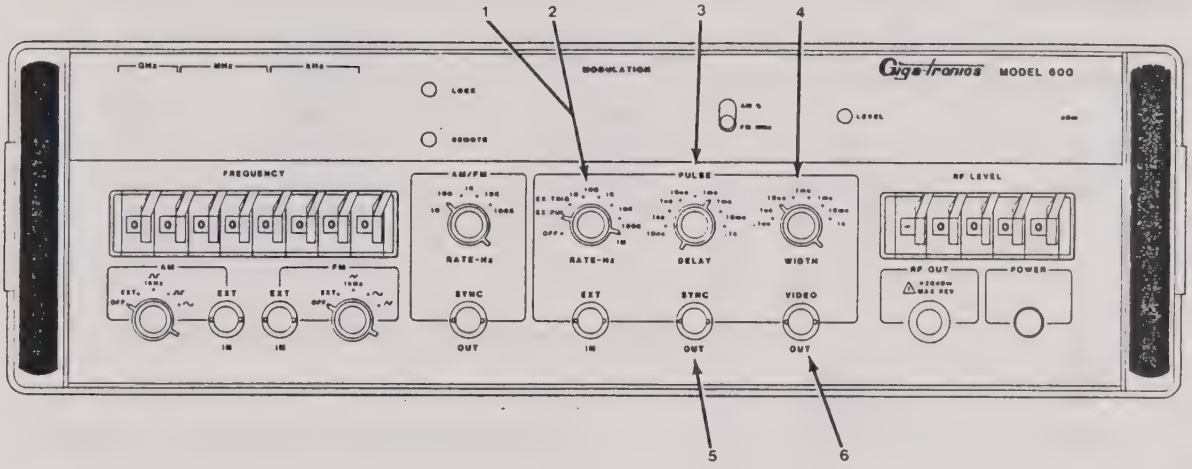


Figure 1.10: Internal pulse mode

1. Select internal pulse mode (place the 'RATE' switch in any of the five internal pulse rate positions)

2. Adjust pulse rate

3. Adjust pulse delay

4. Adjust pulse width

5. Modulation sync pulses are available at the 'SYNC OUT' connector

6. Modulation waveform is available at the 'VIDEO OUT' connector

NOTE: If desired, operation in pulse mode can be simultaneous with operation in the other modulation modes.

1.3 Rear Panel Operation

The following part of section one provides step by step operating procedures for functions implemented on the rear panel.

External ALC

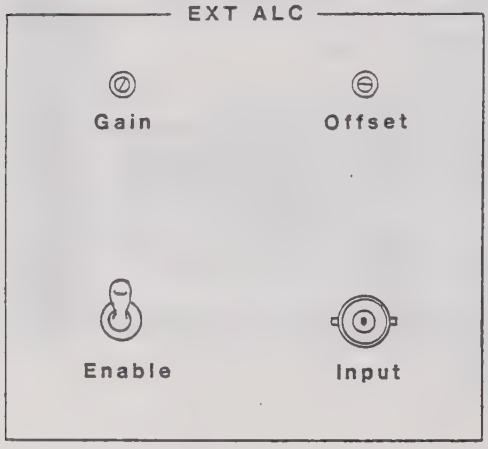


Figure 1.11: External ALC

The external ALC function provides remote leveling capability. The circuit is designed to operate with a directional coupler/diode detector having a standard negative output. Gain and offset adjustments permit calibration of the instrument to match individual detectors. Note that losses in the cable between the instrument RF output and the remote detector will place a limit on both maximum output and leveling range.

1. Connect the remote cable and detector to the instrument output. Connect the coupler/detector output to the rear panel 'EXT ALC' input.

2. Connect a power meter to the detector output and set the 'EXT ALC' switch to the 'ENABLE' position.

3. With the instrument's RF level set to +4 dBm, adjust the rear panel 'GAIN' for a power meter reading of +4 dBm.

4. Set the RF level to -4 dBm and adjust 'OFFSET' for a power meter reading of -4 dBm.

5. Repeat steps 3 and 4 as needed.

External Master Reference

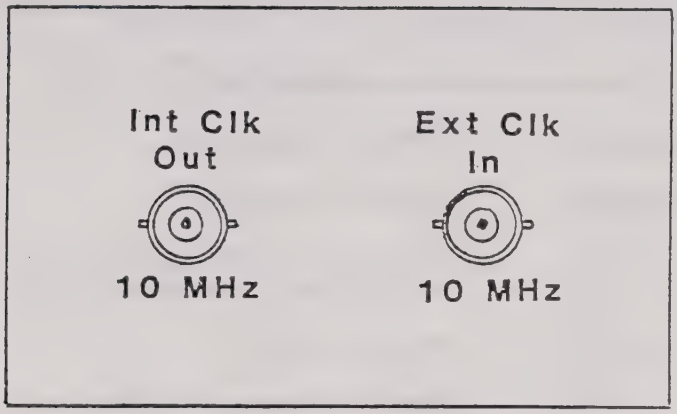


Figure 1.12 External master reference

The clock output provides a buffered 10 MHz signal derived from either the internal master reference or any external signal applied. This output will drive a 50 ohm load to >1 Vpp.

The clock input accepts an external 10 MHz standard with an amplitude between .5 and 5 Vpp. The accuracy of the standard must be within 1 part per million to insure that the instrument will lock to it. The instrument will automatically switch to the external reference when a signal is present.

1.4 External Programming (IEEE-488 Interface)

The Series 600 permits data bus control in accordance with the IEEE Standard Digital Interface for Programmable Instruments IEEE-STD 488-1978.

The following subsets of the standard are implemented:

SH1	Source Handshake	Complete Capability
AH1	Acceptor Handshake	Complete Capability
T8	Talker	Basic Talker, No Serial Poll No Talk Only, Unaddress if MLA
TE0	Extender Talker	No Capability
L4	Listener	Basic Listener, No Listen Only, Unaddressed if MTA
LE0	Extended Listener	No Capability
SR0	Service Request	No Capability
RL2	Remote/Local	No Local Lockout
PP0	Parallel Poll	No Capability
DC0	Device Clear	No Capability
DT0	Device Trigger	No Capability
C0	Controller	No Capability

1.4.1 IEEE-488 Hardware Configuration

INTERFACE CONNECTOR

The following table indicates the pin assignments for the rear panel 24 pin IEEE-488 interface connector.

Contact	Signal Line
1	D101
2	D102
3	D103
4	D104
5	E01
6	DAV
7	NRFD
8	NDAC
9	IFC
10	SRQ
11	ATN
12	Shield
13	D105
14	D106
15	D107
16	D108
17	REN
18	GND (6)
19	GND (7)
20	GND (8)
21	GND (9)
22	GND (10)
23	GND (11)
24	GND Logic

The contact assignments are those required by the IEEE-488 standard. Thus, most users need only connect a standard interface cable between their controller and the 600 interface connector.

ADDRESS ASSIGNMENT

The remote control address is assigned by the five small switches next to the interface connector. Switch 1 is the LSB; and switch 5 is the MSB. Thus, to assign the 600 an address of 6 (listen address '&' and talk address 'F'), the switches would be set as follows:

Switch number	1	2	3	4	5
Switch setting	0	1	1	0	0

SYNTAX CONFIGURATION

The standard remote control syntax (as described in this manual) is enabled by setting S7 on the CPU PC board (A4) to the on (up) position. S7's off position is reserved for enabling a special syntax which might be required in unusual applications. The instrument is normally shipped from the factory with S7 set to the on position.

1.4.2 General Command Structure

CHARACTER REPRESENTATION

In this manual, the ASCII characters sent in a message will be represented in single quotes.

e.g.: 'MESSAGE' corresponds to a string of seven bytes whose hexadecimal values are $4D, $45, $53, $53, $41, $47, $45.

Special characters will be represented as follows:

'<CR>'	Carriage return, $0D
'<LF>'	Line Feed, $0A
'b'	One or more spaces $20
'z'	Zero or more spaces
's'	One space
'd'	Decimal digit

COMMAND INTERPRETATION

The 600 uses a 40 character buffer to accept and store characters sent to it via the interface. Multiple sequential spaces are compressed to a single space character for storage in the buffer. The buffer's contents are interpreted and the buffer is reset upon receipt of a character sent with the EOI line asserted or upon receipt of any of the following delimiter characters:

'<CR>' '<LF>' ',' ':' ';' '/' '\'

Multiple commands may be sent in a single message if they are separated from each other by a space or one of the above delimiter characters. If the commands are separated by spaces, they will not be interpreted until the entire message has been sent. (Note that if spaces are used to separate commands, care must be taken to assure that the 40 character buffer does not overflow: buffer overflow may cause some commands to be ignored.) If the commands are separated by delimiters, each command will be interpreted individually upon receipt. Unless the delimiter used is a carriage return, a potential problem exists when entering multiple commands separated by delimiters: if one of the commands is entered erroneously, it will be ignored and the correct commands accepted after only a momentary error display. The error message may not be displayed long enough to be read.

COMMAND FORMAT

Each command consists of a verb, followed by zero or more spaces, followed by an argument.

e.g.: 'AMzSINE' AM is the verb and SINE is the argument

'FAz12.3E+3 FA is the verb and 12.3E+3 is the argument

NUMERIC ARGUMENTS

Frequency and level setting commands use numeric arguments (represented in command descriptions as 'n'). The format for numeric arguments (described below) is sufficiently flexible that no special formating will be necessary when using most IEEE-488 controllers. Signed or unsigned numbers are acceptable. Integers or decimal fractions are permitted and may be followed by a signed or unsigned one or two digit exponent. Leading zeroes are permitted, but spaces within a number are not permitted. The integer and optional fractional part are each restricted to a maximum length of 10 digits.

The following are examples of valid numeric arguments:

'b25.7' / '-32.1' / '0.3' / '2958.763E-2'

'6E-10' / '-000.000000001E+10' / 'b7b' / '1E6'

1.4.3 Command Descriptions

Each subsection describes a verb and its valid arguments. Most commands perform functions in a way that is similar to the 600's front panel controls, except where noted.

'AM' (set amplitude modulation mode)

'AMzOFF': amplitude modulation off
'AMzEXT': external AM
'AMzFIXED': internal AM, fixed 1 kHz square wave
'AMzSQR': internal AM, variable-rate square wave
'AMzSINE': internal AM, variable-rate sine wave

'FM' (set frequency modulation mode)

'FMzOFF': frequency modulation off
'FMzEXT': external FM
'FMzFIXED': internal FM, fixed 1 kHz triangle wave
'FMzSINE': internal FM, variable-rate sine wave
'FMzTRI': internal FM, variable-rate triangle wave

'PULSE' (set pulse modulation mode)

```
'PULSEzOFF':   pulse modulation off
'PULSEzEXT':   external pulse mode
'PULSEzTRIG':  external trigger mode
'PULSEzINTzA': internal pulse mode, 10-100 Hz range
'PULSEzINTzB': internal pulse mode, 100 Hz-1 kHz range
'PULSEzINTzC': internal pulse mode, 1-10 kHz range
'PULSEzINTzD': internal pulse mode, 10-100 kHz range
'PULSEzINTzE': internal pulse mode, 100 kHz-1 MHz range
```

NOTE: If the range suffix is omitted from the 'PULSEzINT' command, the instrument defaults to the 'B' range (100 Hz to 1 kHz).

'DELAY' (set pulse delay--not applicable to external pulse mode)

```
'DELAYzA': 10-100 nanosecond range
'DELAYzB': 100 nanosecond-1 microsecond range
'DELAYzC': 1-10 microsecond range
'DELAYzD': 10-100 microsecond range
'DELAYzE': 100 microsecond-1 millisecond range
'DELAYzF': 1-10 millisecond range
'DELAYzG': 10-100 millisecond range
```

'WIDTH' (set pulse width--not applicable to external pulse mode)

```
'WIDTHzA': 100 nanosecond-1 microsecond range
'WIDTHzB': 1 microsecond-10 microsecond range
'WIDTHzC': 10 microsecond-100 microsecond range
'WIDTHzD': 100 microsecond-1 millisecond range
'WIDTHzE': 1 millisecond-10 millisecond range
'WIDTHzF': 10 millisecond-100 millisecond range
```

'PANEL' (enable front panel modulation vernier)

```
'PANELzAM':    front panel AM rate vernier activated
'PANELzFM':    front panel FM rate vernier activated
'PANELzRATE':  front panel pulse rate vernier activated
'PANELzDELAY': front panel pulse delay vernier activated
'PANELzWIDTH': front panel pulse width vernier activated
```

'PRESET' (substitute preset pot for front panel modulation vernier)

```
'PRESETzAM':    preset AM rate pot activated
'PRESETzFM':    preset FM rate pot activated
'PRESETzRATE':  preset pulse rate pot activated
'PRESETzDELAY': preset pulse delay pot activated
'PRESETzWIDTH': preset pulse width pot activated
```

'EXTALC' (enable/disable external ALC)

'EXTALCzON': Enables
'EXTALCzOFF': Disables

1.4.4 Set Frequency Command

This command requires a numeric argument, specifying the frequency in MHz. Up to three digits may be given to the right of the decimal, permitting the frequency to be specified to the nearest 1 kHz (e.g., 'n' = 4499.325 specifies 4.499325 GHz). The instrument's frequency resolution is 1 kHz; digits specifying a higher resolution are rounded to the nearest 1 kHz.

'FAzn' (set frequency to 'n')

1.4.5 Set Level Command

The set level command requires a numeric argument, specifiying a level in dBm with .1 dB resolution. Digits specifying a finer resolution are rounded to the nearest .1 dB.

The 'LEVEL' command causes appropriate values for the step attenuator and leveling loop programming to be computed from the argument. The computation causes the step attenuator to switch at argument values which are evenly divisible by 10 (e.g., between '-29.9' and '-30.0).

'LEVELzn' (set output level to 'n')

The argument specifies the output level in dBm. Valid argument ranges are:

$-119.9 \leq$ 'n' $\leq +15.0$

Leveling loop range limitations

The leveling loop range is limited by the maximum output power which the instrument can produce. At very low levels, the on/off ratio of the instrument's PIN attenuators may also limit the loop's range. When the loop's dynamic range is exceeded, the front panel level light will go out.

'ERRORs2' will be issued upon receipt of invalid level command arguments. Leveling loop accuracy is reduced at very low levels (below about -11 dB).

1.4.6 Reply Messages

A reply message will be sent over the interface by the 600 whenever it is addressed to talk. If unaddressed in the middle of a message, any remaining characters are cleared from the output buffer. EOI is

asserted during the last character ('<LF>') of each message.

STATUS MESSAGE

The message normally sent is:
'sLOCKsdsLEVELsds<CR><LF>'
where each 'd' is either '1' or '0' to represent true or false. 'LOCK' and 'LEVEL' are true when their corresponding front panel lights are on.

ERROR MESSAGE

When an error condition exists, the message sent is 'sERRORsdd' where 'dd' is the error code displayed on the front panel. Individual error messages are as follows:

ERROR 1 -- requested frequency out of range
ERROR 2 -- requested level out of range
ERROR 3 -- generator set to illegal bus adress (all switches on)
ERROR 10 -- illegal input word (remote)
ERROR 11 -- illegal input number (remote)

1.4.7 Interface Initialization Values

The IEEE-488 interface is initialized upon assertion of IFC by the controller, upon instrument power up (CPU reset), and whenever the rear panel address switch settings are changed. The 600's remote control data are initialized to a "no modulation" condition. Frequency and output level are initialized to the minimum values.

PERFORMANCE SPECIFICATIONS

Frequency Characteristics

FREQUENCY RANGE: 5.4-12.5 GHz

FREQUENCY RESOLUTION: 1 MHz (standard)
1 kHz (instruments with option 03)

FREQUENCY ACCURACY/STABILITY: Same as time base

INTERNAL TIME BASE FREQUENCY/ACCURACY: 10 MHz, ± 1 X 10E-6

INTERNAL TIME BASE STABILITY: <1 X 10E-6/year (standard)
<1 X 10E-9/day (with option 06)

EXTERNAL TIME BASE: 10 MHz, ± 1 X 10E-6 or better, 0.5 Vpp (overrides internal time base)

TIME BASE OUTPUT: Buffered 10 MHz, 2 Vpp into 50 ohms (derived from internal or external time base)

Spectral Purity

HARMONICS, SUBHARMONICS: <-40 dBc

SPURIOUS (NON-HARMONICS): <-55 dBc

POWER LINE/FAN RELATED: <-45 dBc

SSB PHASE NOISE: <-75 dBc/Hz (typical) at 10 kHz offset, 1 Hz BW

Output Characteristics

OUTPUT LEVEL RANGE: -110 dBm to +10 dBm

OUTPUT LEVEL RESOLUTION: 0.1 dB

OUTPUT LEVEL ACCURACY: ± 2 dB

LEVEL FLATNESS: ± 1 dB

LEVEL DISPLAY FORMAT: 5-digit display; 0.1 dB resolution

OUTPUT IMPEDANCE: 50 ohms, nominal

OUTPUT CONNECTOR: type-N female

OUTPUT VSWR: <2:1

EXTERNAL ALC: Negative crystal detector; gain and offset adjustments provided

REVERSE POWER PROTECTION: Will accept the following signal levels at the output connector without resulting damage: 4 W average power, 3.5 kW peak power

Pulse Modulation Characteristics

PULSE RATE: 10 Hz to 1 MHz (internal or external)

PULSE DELAY: 10 nanoseconds to 100 milliseconds

PULSE WIDTH: 100 nanoseconds to 100 milliseconds (internal), >100 nanoseconds (external), >75% duty factor

RISE/FALL TIMES: <50 nanoseconds (RF, SYNC, and VIDEO outputs)

SETTLING TIME: ± 1 dB within 100 nanoseconds

ON/OFF RATIO: >80 dB

EXTERNAL MODULATION INPUT: TTL compatible, 10 Hz to 1 MHz, positive level for RF "on"

SYNC OUTPUT: +1 V pulse into 50 ohms, width approx. 50 nanoseconds, follows modulation rate

VIDEO OUTPUT: TTL compatible, follows modulation rate and width

Amplitude Modulation Characteristics

MODULATION RATE: 10 Hz to 50 kHz (3 dB points referenced to 1 kHz), square or sine (internal), any waveform (external) 1 kHz fixed square (internal)

DEPTH: 0 to 82% (0 to 20 dBm), min

INPUT SENSITIVITY: 1 Vpp = 50% modulation at 1 kHz rate

INPUT IMPEDANCE: 600 ohms, BNC

DISTORTION: <10% at 1 kHz rate, 50% depth (sine wave)

DISPLAY ACCURACY: ± 10% at 1 kHz rate, 50% depth

Frequency Modulation Characteristics

MODULATION RATE: 10 Hz to 1 MHz (external)
10 Hz to 100 kHz sine or triangle (internal)
1 kHz fixed triangle (internal)

DEVIATION: ± 5 MHz, peak

INPUT SENSITIVITY: 2 Vpp for maximum deviation

INPUT IMPEDANCE: 50 ohms (nominal), BNC

DISTORTION: <5% at 500 kHz rate, 5 MHz peak deviation

DISPLAY ACCURACY: ± 10% at 100 kHz rate, 3 MHz peak deviation

General

REMOTE INTERFACE: IEEE STD 488-1978

WARM-UP TIME: 20 minutes, max

OPERATING TEMPERATURE RANGE: 0 to +50°C

ENVIRONMENTAL REQUIREMENTS: Type tested to MIL-T-28800C, type III, Class 5, Style E, Color R

POWER: 100/120/220/240 VAC ± 10%, 50-400 Hz, 200 watts max

DIMENSIONS: 16.75" X 5.25" X 18"; 40 lbs nominal

CALIBRATION INTERVAL: 9 months

SECTION THREE

THEORY OF OPERATION

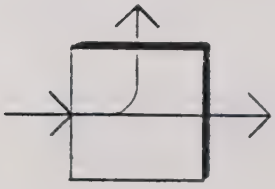
GLOSSARY OF SYMBOLS

The following is a glossary of the block-diagram symbols used in this manual. Some of them are unusual figures devised to meet the special descriptive requirements of microwave synthesizers.

DIGITAL INFORMATION -- Data or instructions coded in binary form, used by the system computer to control the instrument and its various circuits.

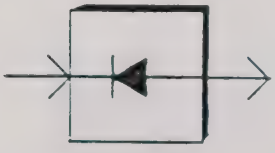
DIGITAL TO ANALOG CONVERTER -- A circuit which receives a binary number in digital code, and produces an output analog signal, the amplitude of which is proportional to the binary number.

AMPLIFIER/DRIVER/BUFFER -- A circuit which conditions the analog output of one circuit to make it compatible with the input requirements of another circuit.



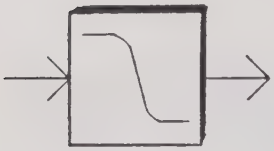
COUPLER -- A device which, by induction, takes a sample of the signal passing through it for use in auxilliary circuits.

STEP-ATTENUATOR -- A programmable device which attenuates (reduces the power of) the signal passing through it by fixed increments.

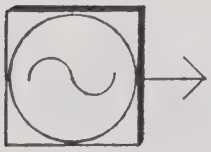


DETECTOR -- A device used to measure the power level of the RF signal applied to it. The detector produces a negative voltage proportional in amplitude to the detected power.

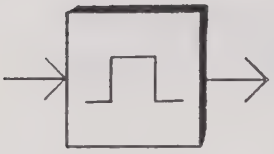
FREQUENCY DIVIDER -- A circuit which accepts a frequency input, and produces a frequency output equal to the input divided by some number.



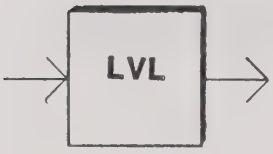
LOW-PASS FILTER -- A circuit designed to pass relatively low frequencies while suppressing relatively high frequencies; often used to block undesired harmonics.



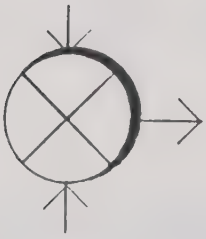
MASTER REFERENCE -- The highly stable fixed 10 MHz signal to which all oscillators in the system are phase-locked. The standard timebase is a quartz oscillator built into the instrument; any external 10 MHz source can be substituted for it simply by connecting the source to the reference input.



PULSE MODULATOR -- A PIN diode circuit used as a solid-state switch in order to turn the signal passing through it on and off; located inside the RF module.



LEVELER -- A PIN diode circuit used as a variable attenuator in order to control the power of the signal passing through it; located inside the RF module.



MIXER -- A device which produces an "intermediate frequency" (IF) equal to the difference between its two input frequencies, or equal to the sum of its two input frequencies.

VOLTAGE CONTROLLED OSCILLATOR (VCO) -- An oscillator, the output frequency of which can be adjusted by means of a control voltage.

YIG-TUNED TRANSISTOR OSCILLATOR (YIG) -- A microwave frequency oscillator, named for its tuning element which is composed of Yttrium-Iron-Garnet. Coarse and fine frequency adjustment are performed by controlling the current through two tuning coils.

STEP-RECOVERY DIODE MULTIPLIER -- A device that produces an output signal rich in harmonic multiples of the input frequency.

PHASE DETECTOR -- A circuit which compares two frequency inputs (a fixed reference frequency and a variable frequency), determines the phase relationship between them, and generates output pulses having widths proportional to the degree of phase difference. The pulses appear at either of two outputs, depending on whether the variable input leads or lags the reference.

PHASE LOCK LOOP -- A circuit which combines a phase detector with a filter and amplifier. The filter and amplifier covert the phase detector pulse outputs into a control signal, which tunes the variable oscillator so that the phase difference between the two phase detector inputs is reduced.

GENERAL CONFIGURATION OF THE INSTRUMENT

The Model 600 is a single-band microwave generator which employs a YIG oscillator, tuned by a phase lock loop system, to synthesize its RF output. All output frequencies are phase locked to a 10 MHz master reference, and may be selected in increments of 1 MHz (1 kHz for instruments with option 03). Output power is controlled by a leveling system, and may be selected in increments of 0.1 dB; a 10 dB step attenuator on the output is used to adjust the power in larger increments. The RF output may be internally or externally modulated in a variety of AM, FM and pulse modulation modes. Internal function generators offer a choice of modulation signals. Remote operation is made possible by an IEEE-488 interface bus. All functions of the instrument are controlled by an internal computer.

Circuit boards A1 through A4 are plugged into the CPU bus board (A102) and constitute the internal computer. A5, also plugged into the CPU bus, is the level control board.

Circuit boards A6 through A13 are plugged into the RF bus board (A103); these are the high-frequency circuits used to synthesize the instrument's output signal, including the phase lock loops and the YIG driver. The RF bus board itself also houses the FM driver circuit. Circuit boards A9 and A10 are present only in instruments with option 03 (1 kHz Resolution).

The microwave deck includes the YIG oscillator, the RF module, the enclosed 300 MHz oscillator board (A104), the enclosed 110 MHz oscillator/multiplier board (A113), and the 10 dB step attenuator.

The modulation generator board (A105), together with the smaller delay/width generator board which is mounted on it (A106), are located at the base of the front panel.

The power supply is located behind and adjacent to the CPU bus.

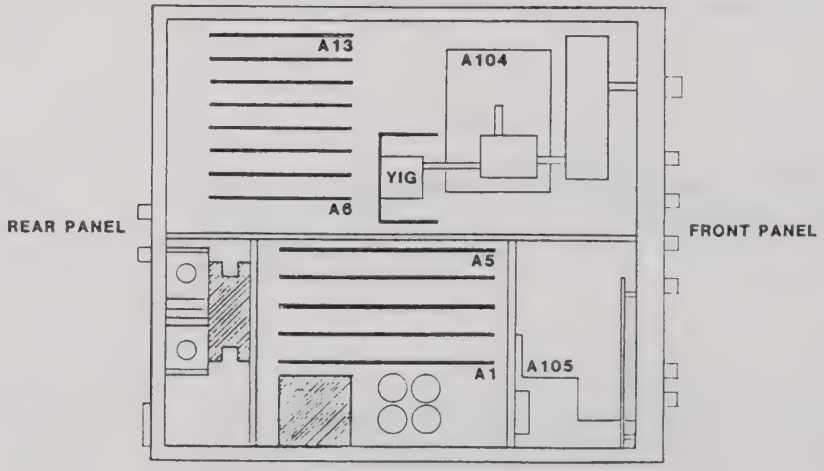


Figure 3.1: Series 600 Interior Layout

THE COMPUTER

An internal computer is used to control the Model 600. The computer is organized around a Motorola 6809 microprocessor with its internal clock controlled by a 3.579 MHz crystal. This clock frequency was selected to minimize beat notes generated by its harmonics and the various frequencies generated within the instrument.

The microprocessor controls, and communicates with, other circuits by means of Peripheral Interface Adapters or PIAs. These devices act as windows through which information and instructions are transmitted to and from the 6809's 8-bit data bus. The data bus is used to send control signals (including multiple-bit numbers in parallel) to the various functional sections of the instrument, and also to take in data from those locations. Digital/analog and analog/digital conversion are used by the computer in order to generate and measure analog signals.

The microprocessor's 16-bit address bus can access up to 64K of memory. Much of this memory capability is not presently used by the Model 600, so there remains room for expansion. Because control software can be rewritten more readily than control hardware can be rebuilt, Giga-tronics's memory-intensive approach has made this an extremely adaptable instrument.

Giga-tronics produces its own computer software, which is stored in PROM devices on the memory board (A2); also in that location are RAM devices used for temporary data storage. A "reset" PROM located on the CPU board itself (A4) contains initialization data, level characterization data, and other information unique to the individual instrument.

The microprocessor, the PIAs, and the semiconductor memory devices will be referred to collectively as the computer. The computer generates and receives digital data required for operation of almost every instrument function. It receives and interprets the operator's commands, through either the front panel switches or the remote interface; it returns information to the operator, through either the front panel displays or the remote interface; it selects appropriate reference frequencies, intermediate frequencies and divisors to generate the RF output; it tunes the YIG oscillator; it activates the appropriate harmonic filter line for the RF path; it controls the power level and the modulation of the RF output; it monitors the functioning of the instrument and supplies error messages and fault indicators to the operator.

THE RF PATH

Coupling, leveling, modulation, filtering, and attenuation of the output signal are accomplished in the path between the YIG oscillator and the instrument's RF output connector. Some power loss inevitably takes place in this RF path; Giga-tronics has cut this loss to a minimum, by using printed microstrip conductors and miniature components to create a hybrid circuit which incorporates most of the above functions into a single module. This clustering of RF circuits greatly reduces the power loss inherent in designs requiring multiple transitions and connectors.

Samples of the RF output signal are required by two circuits outside the RF path. Microstrip couplers located within the module are used to return

portions of the RF signal to the output phase lock loop (by way of the sampling mixer) and to the level detector.

A leveler circuit within the module, consisting of PIN diodes, functions as a variable attenuator. A signal from the level control circuit regulates current through these diodes in order to adjust output power.

The output of a YIG oscillator is not spectrally pure. Harmonics of the fundamental frequency are usually present at amplitudes of -12 to -20 dBc. Low-pass filters (consisting of shaped microstrip elements) are used to eliminate these harmonics, and the path through the RF module is subdivided into either two or three filter lines, depending on output bandwidth. The switching of these paths is performed by PIN diode circuits, rather than by mechanical switches, for increased reliability.

The filter switch circuits are also used to pulse-modulate the RF output (the pulse modulation input is applied to the switch that controls the appropriate filter line). A second pulse modulation input is used to switch a 50 ohm termination into the RF path ahead of the filter switches during pulse "off" intervals. This is necessary because, during the "off" period, the RF path is opened and loses its output termination. If an additional termination were not switched into the circuit, reflected power would be picked up by the level coupler and would interfere with level control.

The output of the RF module is applied to the 10 dB step attenuator, which is connected directly to the front panel. Interconnections between components in the RF path are made through semi-rigid coaxial cable (waveguide is not required for the frequencies generated by instruments in the 600 series).

AMPLITUDE CONTROL

The output amplitude of the instrument is controlled by a combination of fixed-step attenuation and closed-loop leveling.

The output stage of the synthesizer consists of a step attenuator which provides up to 110 dB of attenuation in 10 dB increments. Finer control of the output level is provided by the closed loop leveling system, also referred to as Automatic Leveling Control or ALC.

The level control circuit is basically a loop amplifier with multiple inputs, of which one is feedback from the level detector, a device which returns a negative voltage proportional to the square of detected power. The RF measured by the detector is coupled from the output path by a circuit in the RF module (during operation in the external ALC mode, a remote detector is substituted for the internal one). The detector signal is amplified and applied to the summing junction of the leveling loop amplifier; it may be considered the "variable" input, in that it changes in response to the loop amplifier's output.

The "reference" input to the loop amplifier is a composite of three signals: a correction voltage from the temperature compensation circuit (A112), a fixed leveling input which the system computer programs by means of a digital to analog converter, and the AM signal, if any, from the modulation generator board (A105). The AM signal is processed by a logarithmic amplifier to give

it the same logarithmic characteristic as the other two inputs, so that all three can be combined by a summing amplifier. The combined signal is processed by an antilogarithmic amplifier on its way to the loop amplifier.

The loop amplifier output is applied to an amplifier which drives the PIN diode leveler in the RF module; the amplifier drives the leveler so as to balance the "reference" input against an equal and opposite "variable"

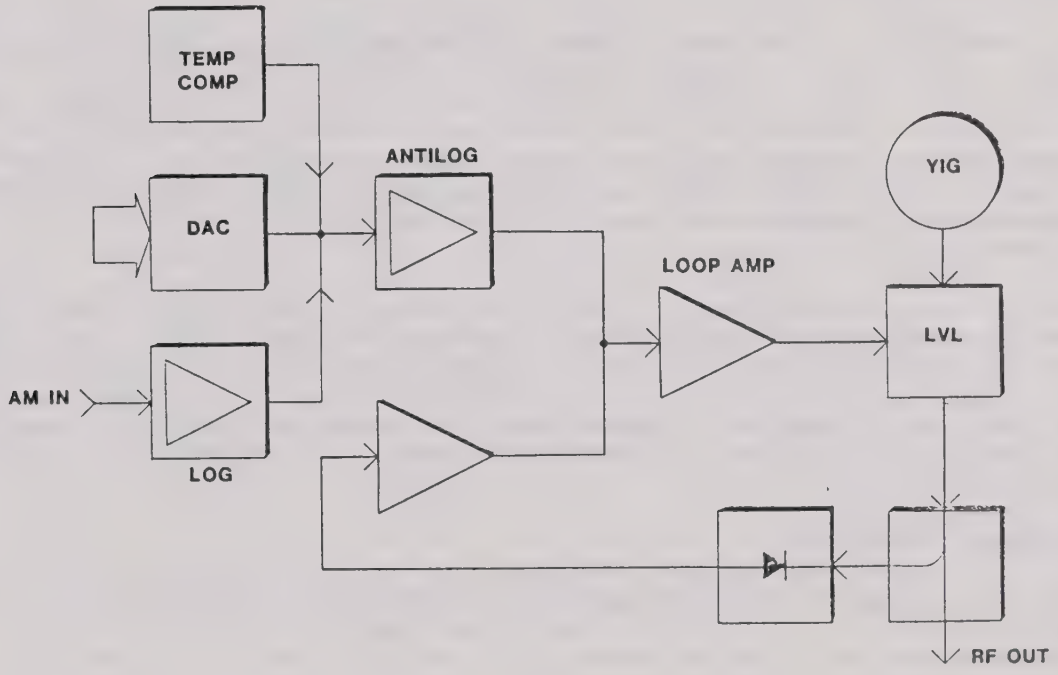


Figure 3.2: Amplitude Control

feedback input. In other words, the leveler adjusts RF power until the detector feedback input just cancels the other input to the loop amplifier.

In setting the leveling reference (through the programming of a digital to analog converter), the system computer includes compensation factors from a level-characterization table stored in the instrument's "reset" PROM (see A4). This data is individual to the instrument and is compiled during production testing.

AMPLITUDE MODULATION

As described above, one component of the reference input to the loop amplifier in the level control circuit (A5) is an amplitude modulation input. This input comes from the modulation generator board (A105), where it is derived from the internal or external modulation signal. This board also houses the logic circuits by which the modulation mode is selected under either local or remote control, as well as the function generator used to produce internal modulation signals.

The AM input to the level control circuit (processed by a log amplifier to match it to the logarithmic characteristic of the computer's leveling reference and the temperature compensation input) supplies the leveling loop amplifier with a variable, rather than a fixed, leveling reference. The level control circuit furnishes a modulated control voltage to the leveler in the RF module in order to match the modulation of the reference. The result is an amplitude modulated RF output, with a modulation depth of up to 70%.

PULSE MODULATION

Pulse modulation is performed by means of path-switching circuits in the RF module. Depending on output bandwidth, there will be either two or three filter paths through the module, of which only one is active at a time. PIN diode circuits are used to switch these lines on and off; pulse modulation is accomplished by shutting off the active path intermittently (a positive voltage at the filter line's control pin on the outside of the module shuts the path off). By this method, an on/off ratio of greater than 80 dB can be achieved.

The drive signals used in pulse modulation originate on the pulse generator board (A106) and the modulation generator board (A105), and are derived from the internal or external modulation signals by circuits which also furnish the sync and video outputs. The internal signal generator, as well as the width and delay generators, are located on these boards, as are the logic circuits by which the modulation mode is selected under either local or remote control.

FREQUENCY MODULATION

Frequency modulation of the RF output is achieved by modifying the fine tuning of the YIG oscillator. The current supply to the YIG's fine tuning coil is controlled by the FM driver (A103), which in turn is controlled by the output phase lock loop circuit (A6). Normally, the PLL's driver output is derived from the outputs of the phase comparator, suitably filtered and amplified. During operation in the FM mode, however, this phase comparator signal is summed with a modulation signal, providing a modulated drive and resulting in a frequency modulated output from the YIG oscillator.

The FM signal furnished to the output PLL originates on the modulation generator board (A105), and is derived from the internal or external modulation signal. This board also houses the logic circuits by which the modulation mode is selected under local or remote control, as well as the function generator used to produce internal modulation signals.

FREQUENCY SYNTHESIS

The output frequency of the Model 600 is produced by a YIG oscillator. Coarse tuning of the YIG is performed by the YIG driver circuit (A13), a programmable current source which the system computer controls by means of a digital to analog converter and amplifier. This current source (connected to the YIG's "tuning" coil) can bring the YIG frequency within 50 MHz of the desired value. Fine tuning of the YIG is accomplished by the output phase lock loop, which supplies a controlled tuning current to the YIG's "FM" coil. The synthesis process used by the Model 600 involves up to six phase lock loops, depending on output frequency resolution. The following is an introduction to phase lock loop circuits.

PHASE LOCK LOOPS

The purpose of a phase lock loop (PLL) is to control a variable frequency oscillator so that its output frequency has the same accuracy and stability as that of a fixed reference oscillator. It works by comparing two frequency inputs, one fixed and one variable, and supplying a correction signal to the variable oscillator in order to achieve and maintain a constant phase relationship between the two inputs. The following discussion refers specifically to the phase lock loop circuits used in Giga-tronics signal generators, and is not meant to encompass all types of phase lock loops.

The stability and accuracy of a reference frequency (for example, the signal produced by a 10 MHz crystal oscillator) can be transferred to a voltage controlled oscillator (VCO) by means of a phase lock loop. The 10 MHz signal is applied to the reference input of the PLL, and the VCO output frequency is fed back to the variable input of the PLL. A phase detector in the PLL circuit compares the two inputs and determines whether the variable input is leading or lagging the reference. The phase detector has two outputs; pulses

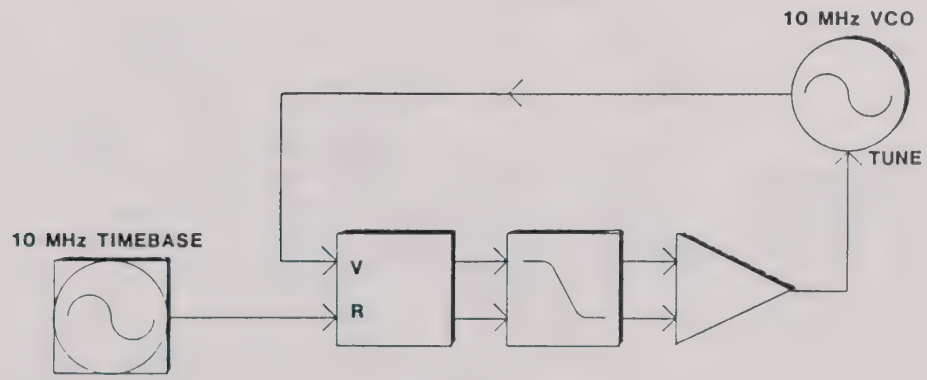


Figure 3.3: Elementary phase lock loop

appear at one of them (which one depends on whether the variable input is leading or lagging), and the width of the pulses is proportional to the degree of phase difference. The pulses are averaged by a low pass filter and DC amplifier into a correction signal, which causes the VCO frequency to increase or decrease in order to reduce the phase difference between the two input frequencies. When the phase error is eliminated, the frequencies are equal, the loop is said to be "locked", and the VCO frequency acquires the accuracy and stability of the reference input.

Although the variable input to the phase detector should equal the frequency of the reference input, it need not equal the frequency of the the VCO. If a frequency divider is introduced between the VCO and the variable input, the VCO can be run at a frequency that is a multiple of the reference frequency. For example, if the VCO output is divided by ten before being applied to the phase detector input, the VCO can run at 100 MHz and still be phase locked to a 10 MHz reference. A frequency divider which intervenes between the VCO and the phase detector's variable input is called a prescaler. If the prescaler is programmable (that is, if it can be set to a given divisor), a variety of frequencies can be phase locked to a single reference frequency.

Since the output frequency must be some multiple of the reference frequency input to the phase detector, the reference frequency limits the resolution of the system: with a 10 MHz timebase, frequencies of 70 MHz or 80 MHz could be generated, but not 73 MHz. This is because digital frequency dividers can perform integer divisions only; the prescaler cannot be programmed to "divide by 7.3". However, if the reference frequency applied to the phase detector is itself programmable, this difficulty can be overcome, either by using a 1 MHz reference frequency and dividing the output by 73, or by using a 7.3 MHz reference and dividing the output by 10.

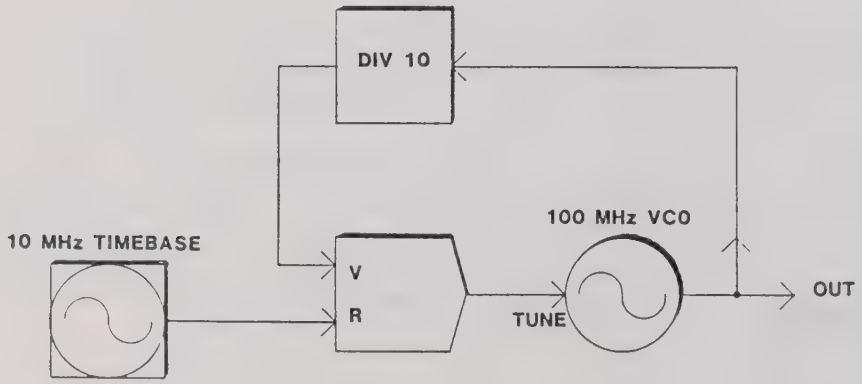


Figure 3.4: 100 MHz phase lock loop.

MICROWAVE FREQUENCY SYNTHESIS

Digital synthesis of microwave frequencies is impeded by two inherent difficulties. First, these frequencies are well above the operating range of digital logic circuits. Second, the bandwidths required tend to be large; even a single-band unit such as the Model 600 must cover an output range of several thousand MegaHertz. A requirement for fine frequency resolution over so wide a range complicates the synthesis process.

In the Model 600, RF mixers are used to downconvert microwave signals to more workable frequencies. Generally, a mixer provides an intermediate frequency equal to the difference between two high-frequency inputs. For example, a step-recovery diode multiplier and an RF mixer (used in a combination known as a sampling mixer) are used to derive a low frequency I.F. equal to the difference between the output microwave signal and some harmonic of a stable 100 MHz input. The various reference signals used to synthesize the output are generated at, or mixed down to, frequencies low enough to drive digital circuits (usually below 200 MHz).

The problem of bandwidth, insofar as it limits frequency resolution, is overcome through the use of compounded PLL circuits to produce reference frequencies programmable in 1 MHz increments over a wide range. For an instrument with Option 03, six different phase detectors are employed in the loops within loops which synthesize the output signal; the benefit purchased by this seemingly high degree of complexity is an output resolution of 1 kHz (one part in 8 million for a Model 600 having an 8 GHz output bandwidth).

THE SYNTHESIS NETWORK

All output frequencies are synthesized by the output PLL, and are ultimately phase locked to the 10 MHz master reference. The synthesizer can be analyzed as two parallel branches connecting the master reference to the output PLL's reference and variable inputs. The variable branch includes feedback from the output YIG oscillator.

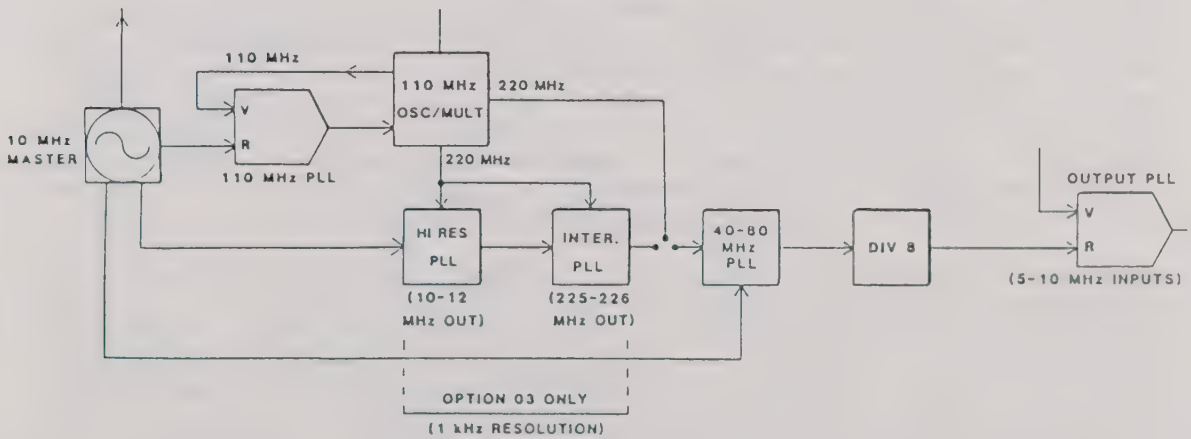


Figure 3.5: The reference branch

THE REFERENCE BRANCH

1 -- 10 MHz master reference (see A12)
2 -- 110 MHz PLL (A12)
3 -- 110 MHz oscillator/multiplier (A113)
3 -- 10-12 MHz PLL (A10, Option 03 only)
4 -- intermediate PLL (A9, Option 03 only)
5 -- 40-80 MHz PLL (A8)
6 -- divide-by-8 (A7)
7 -- output PLL, reference input (A6)

The master reference is the instrument's 10 MHz timebase (either the built-in oscillator or an externally applied reference signal -- see the 10 MHz input/output circuit located on the A12 PC board).

The 110 MHz PLL is used to phase lock the 110 MHz voltage controlled oscillator (on the A113 board) to the 10 MHz timebase. A sample of the VCO frequency is divided by 11 and applied to the variable input of a phase comparator; the timebase is the reference input. The phase comparator output is used to generate a tuning voltage for the VCO. The PLL increases or decreases the oscillator frequency until the phase detector inputs match. The 110 MHz oscillator/multiplier generates the 220 MHz and 330 MHz reference signals that are required by other circuits (including the 10-12 MHz PLL and the intermediate PLL in instruments with Option 03). It contains a 110 MHz VCO (tuned by the PLL circuit described above), a frequency doubler (for the 220 MHz reference), and a frequency tripler (for the 330 MHz reference).

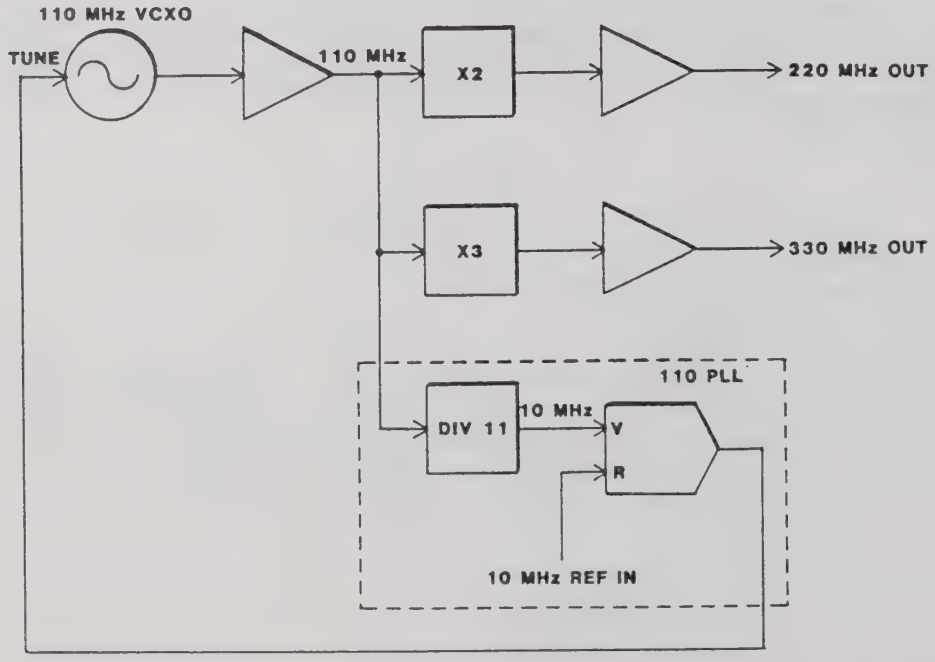


Figure 3.6: 110 MHz Oscillator/Multiplier and Phase Lock Loop

The 10-12 MHz PLL is a programmable source, generating frequencies in 2 kHz increments between 10 and 12 MHz. It is used in instruments with option 03 (1 kHz Resolution). A 250-300 MHz VCO, with a divide-by-25 circuit on its output, is the source of the 10-12 MHz signal. The VCO is tuned by a phase lock loop circuit, but its output is not fed back directly to the phase comparator because the 250-300 MHz frequency range is too high. Instead, the VCO frequency is applied to a mixer. The other mixer input is the 220 MHz reference signal from A113. The 30-80 MHz IF from the mixer is applied to a programmable divider; the divider output (50 kHz when the loop is locked) is applied to the phase comparator's variable input. The reference input is the 10 MHz timebase, divided by 200 for a fixed 50 kHz reference. The PLL tunes the VCO until the two comparator inputs match. The 10-12 MHz output is used by the intermediate PLL as a reference.

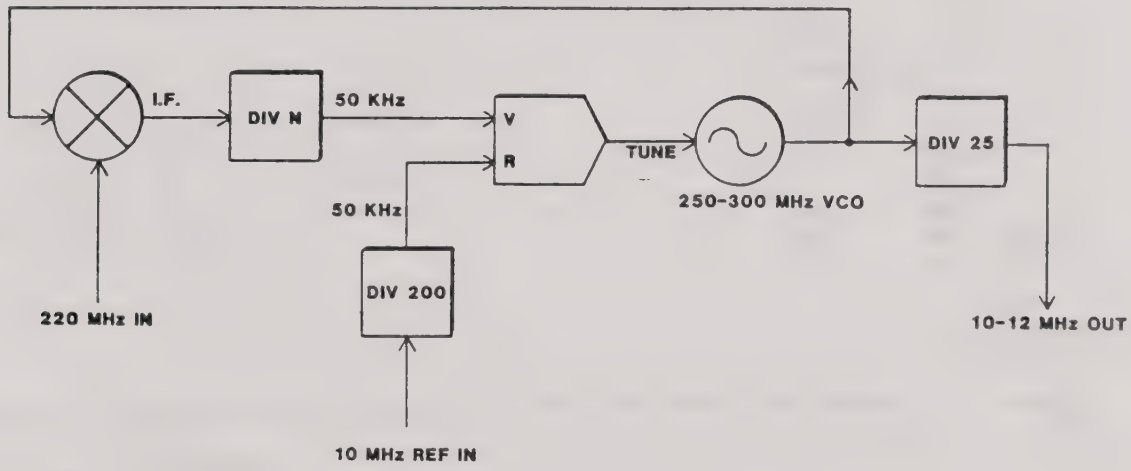


Figure 3.7: 10-12 MHz Phase Lock Loop

The intermediate PLL is a programmable source, generating frequencies in 1 kHz increments between 225 and 226 MHz. It is used in instruments with Option 03 (1 kHz Resolution). A VCO is the source of the 225-226 MHz output. The VCO frequency is fed back to a mixer, where it is combined with the 220 MHz reference input from A113. The resulting 5-6 MHz IF is applied to the variable input of the phase comparator. The 10-12 MHz reference signal from A10 is divided by two and applied to the reference input of the phase detector. The PLL circuit tunes the VCO so as to equalize these two inputs. The 225-226 MHz output is used by the 40-80 MHz PLL as a reference.

The 40-80 MHz PLL is a programmable source, generating frequencies between 40 and 80 MHz. The output frequency is an IF generated by mixing the output of a 266-305 MHz VCO with the 225-226 MHz reference input from the intermediate PLL (A9). In instruments without Option 03, this 225-226 input is replaced by the 220 MHz reference from A113. The VCO is tuned by a PLL circuit; its output is fed back through a frequency divider having a fixed divisor of four, followed by a programmable divider which reduces the feedback signal to 250 kHz and applies it to the variable input of the phase detector. The reference input to the phase detector (also 250 kHz) is obtained by dividing

the 10 MHz reference input by 40. The phase lock loop circuit tunes the VCO until these two inputs match.

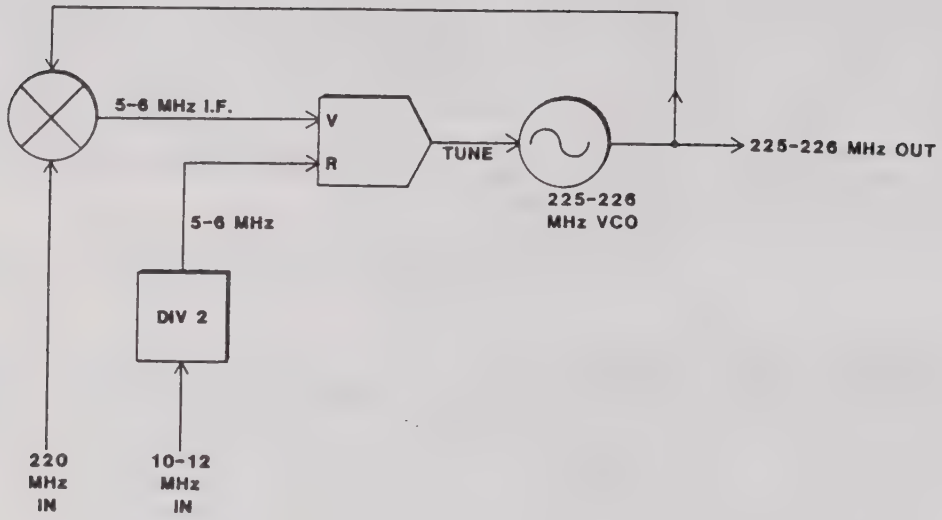


Figure 3.8: Intermediate Phase Lock Loop

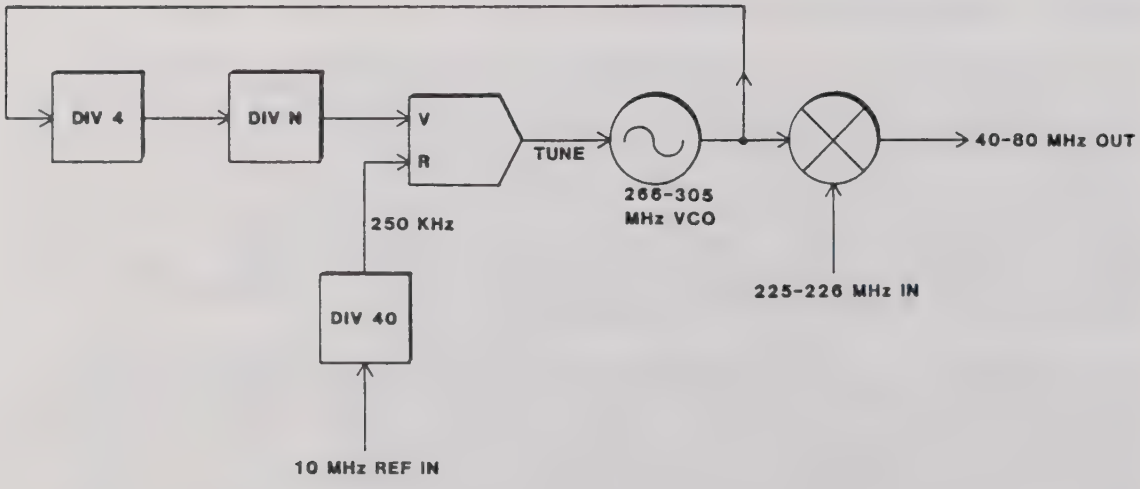


Figure 3.9: 40-80 MHz Phase Lock Loop

The divide-by-8 circuit is a binary frequency divider which accepts the 40-80 MHz reference and divides it by 8; the output signal (a 5-10 MHz reference programmable in 0.125 kHz increments) is the reference input to the output PLL circuit.

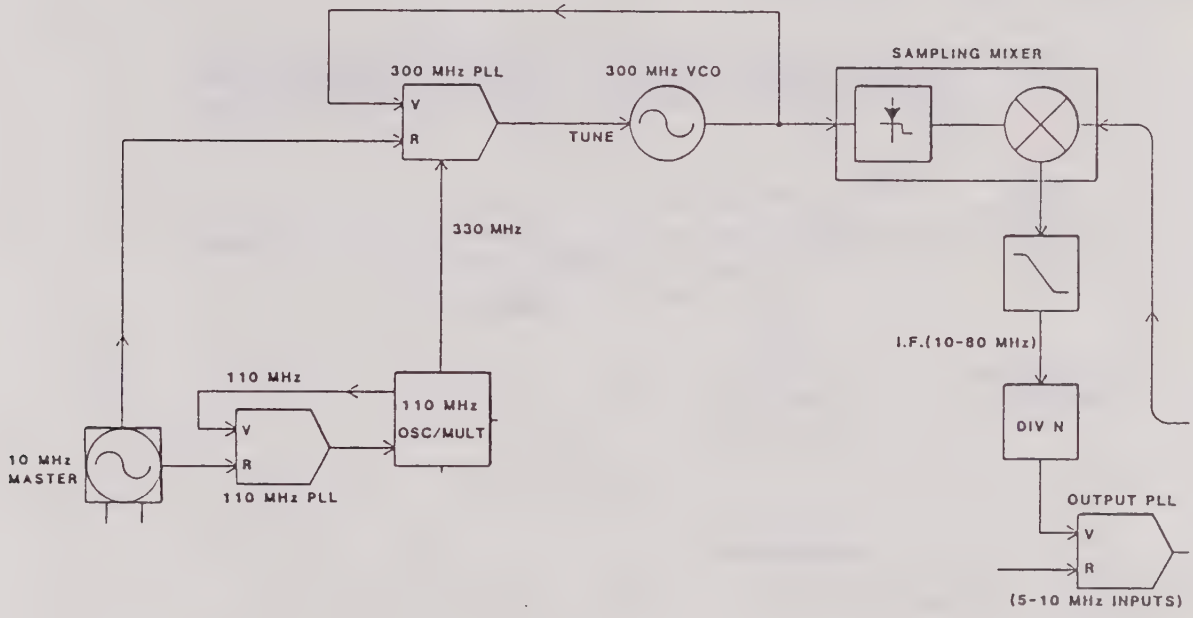


Figure 3.10: The Variable Branch

THE VARIABLE BRANCH

This branch consists of circuits in the following sequence:

1 -- 10 MHz master reference (see A103)
2 -- 110 MHz PLL (A12)
3 -- 110 MHz oscillator/multiplier (A113)
4 -- 300 MHz PLL (A11)
5 -- 300 MHz VCO/driver (A104)
6 -- sampling mixer/IF amplifier (A104)
7 -- divide-by-N (A7)
8 -- output PLL, variable input (A6)

The 10 MHz master reference and the 110 MHz PLL are the same circuits used in the reference branch.

The 110 MHz oscillator/multiplier also supplies a 330 MHz reference input to the 300 MHz PLL.

The 300 MHz PLL is a programmable source, generating frequencies in 1 MHz steps between 284 and 319 MHz. A VCO, tuned by a phase lock loop circuit, generates the output frequency. The VCO frequency is mixed with the 330 MHz input (from circuit board A113) to produce an IF which is then applied to a

programmable divider; the IF is reduced to 1 MHz and applied to the variable input of the phase detector. The reference input, also 1 MHz, is obtained by dividing the 10 MHz reference input by 10. The PLL tunes the VCO until these two phase detector inputs match.

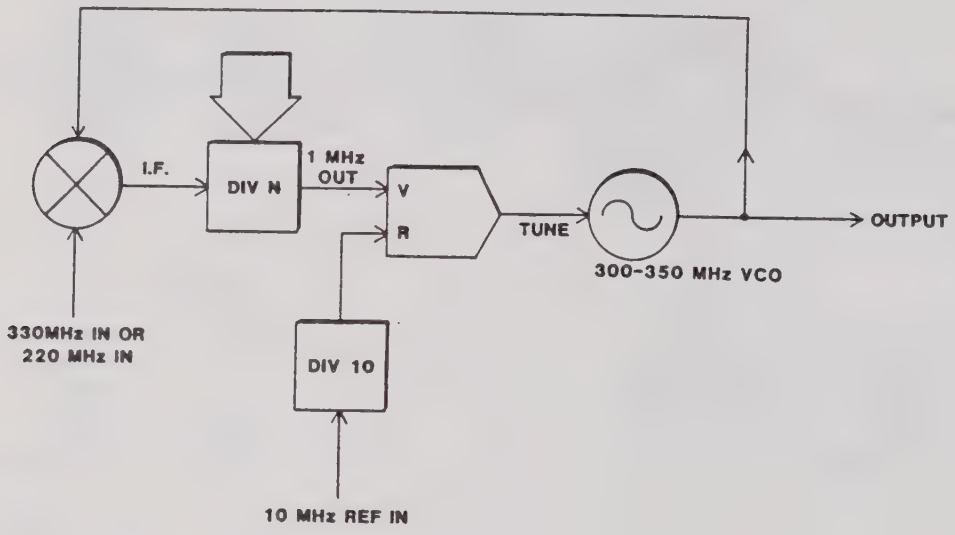


Figure 3.11: 300 MHz PLL/VCO

The 300 MHz VCO/driver is controlled by the 300 MHz PLL. Its output is amplified and used to drive the multiplier input of the sampling mixer.

The sampling mixer has a step recovery diode multiplier on one of its inputs (the input driven by the 300 MHz VCO). The multiplier produces a series of frequency components that are harmonics of the input. The other input to the mixer is a signal coupled from the output of the YIG oscillator. The mixer combines the YIG frequency with the harmonics of the VCO frequency, yielding a great variety of intermediate frequency (IF) components. The IF output is amplified and filtered in order to pass only IFs within a 10-80 MHz range. In this way the output is limited to a single IF component, derived from the difference between the YIG frequency and one of the VCO's harmonics. The IF (a signal programmable over a range of 10 to 80 MHz) is applied to the divide-by-N circuit.

The divide-by-N circuit is a programmable frequency divider; the computer programs it to divide the IF by 2, 4, or 8 in order to produce an output frequency in the range of 5 to 10 MHz. The output is applied to the variable input of the output phase lock loop. The amplified and filtered phase detector output of the PLL is further amplified by the FM driver circuit (see A103) before being applied to the YIG's FM coil. The YIG is tuned in order to adjust the sampling mixer IF and thus equalize the reference and variable inputs to the PLL.

The various programmable frequencies are set by the computer, in accordance with a complex algorithm, to produce the requested output frequency.

SECTION FOUR

CALIBRATION AND TESTING

CALIBRATION PROCEDURE

1.0 Required Test Equipment

1.1 Frequency counter covering output frequency range of Series 600; time base accuracy better than 1 part in 10E9; IEEE-488 interface.

1.2 Computer/controller: any unit equipped with IEEE-488 interface, such as HP9825, HP85, PET 2001.

1.3 Power meter/sensor (HP436A with 8485A or equivalent).

1.4 Spectrum analyzer (HP8566 or equivalent, with external mixers as required).

1.5 Oscilloscope (Tektronix 2465 or equivalent).

1.6 Detector (Wiltron 70S50B or equivalent).

1.7 50 ohm termination (Tektronix 011-0049-01 or equivalent).

1.8 Pulse generator (Wavetek 802 or equivalent).

1.9 Low distortion sine wave generator (Wavetek 182A or equivalent).

1.10 FM test fixture (described in this procedure).

1.11 Distortion analyzer (HP 339A or equivalent).

1.12 Modulation meter (Wavetek 4101 or equivalent).

2.0 Master Oscillator Calibration

2.1 Turn on Unit Under Test and allow a 20 minute warmup, covers on.

2.2 Connect the 10 MHz output on the rear panel of the UUT to the oscilloscope vertical input. Adjust oscilloscope for a mid to full scale display; .1 ms/cm timebase setting.

2.3 Connect the output from the frequency standard (10 MHz) to the oscilloscope external trigger input and adjust the oscilloscope to trigger on this signal.

2.4 Remove the UUT top cover and adjust the master oscillator frequency adjust (located under a screw-in cap) until the scope display stands still. Use the X10 expander for more resolution.

2.5 Replace the screw-in cap on the oscillator.

3.0 Output Oscillator Tracking

The frequency range of the output YIG oscillator varies for different models in the 600 series. The MIN and MAX calibration frequencies should be within about 1 GHz of the limits of the instrument's frequency range (for example, an output oscillator having a range of 10-18 GHz should be calibrated at 11 and 17 GHz).

3.1 Turn on UUT, all modulation off, minimum frequency. Allow a 20 minute warmup, covers off.

3.2 Set output for 0 dBm and connect the frequency counter to the front panel RF OUT connector.

3.3 Connect the oscilloscope to the A6 (Output PLL) test point (DC coupled, 1V/cm, GND @ center).

3.4 Adjust the YIG oscillator driver (A13) so that the test point voltage is 0 $\pm$ .5V with the counter reading the selected frequency to 1 MHz resolution. Use the following steps:

STEP	FREQUENCY	ADJUSTMENT
1	"MIN"	(A13) MIN POT
2	"MAX"	(A13) MAX POT
3	(Repeat 1 & 2 as required)	

3.5 Starting at the minimum output frequency, increment the frequency in 100 MHz steps, monitoring the A6 test point. Readjust the appropriate controls, if necessary, to maintain the voltage within 1V of ground across the band.

4.0 RF Output Amplitude Calibration

4.1 Turn on UUT, all modulation off, minimum frequency, level set to -4 dBm. Allow a 20 minute warmup, covers off.

4.2 Adjust the "-4" pot on the A5 board (Level Control) for a reading of -4 dBm as measured by a power meter.

4.3 Set the output level to +4 dBm, and adjust the "+4" pot for a reading of +4 dBm on the power meter.

4.4 Set the output level to +9 dBm, and adjust the "+9" pot for a reading of +9 dBm on the power meter.

4.5 Repeat 4.2, 4.3 and 4.4 as needed.

5.0 AM/FM Rate (start of front panel calibration)

5.1 Turn on UUT, minimum frequency, level set to -4 dBm, modulation set to AM SINE. Allow a 20 minute warmup, covers off.

5.2 Monitor AM/FM SYNC OUT with the oscillocope. The output should be a rectangular wave at levels of zero and +4 Vpp; the duty cycle is not necessarily 50%.

5.3 Turn the AM/FM RATE switch to the second lowest range (100 Hz-1 kHz), vernier fully CCW (minimum setting). Adjust R77 (A105) for a rate of <100 Hz (roughly, 90 Hz).

5.4 Verify a rate of >1 kHz with the vernier fully CW (maximum setting).

5.5 Verify that the higher settings cover their full rate ranges with the vernier at minimum and maximum positions:

First range <10 Hz min, >100 Hz max.
Third range <1 kHz min, >10 kHz max.
Fourth range <10 kHz min, >100 kHz max.

6.0 AM/FM Modulation Meter

6.1 Use the ohm meter to verify the resistance between the center pins and ground for the AM EXT IN and FM EXT IN connectors (the reading should be 600 ohms for the AM input, 50 ohms for FM).

6.2 Turn on UUT, all modulation off, minimum frequency. Allow a 20 minute warmup, covers off.

6.3 Adjust the "DISP ZERO" pot on the A5 board for a modulation meter reading of 0.00% (AM position) and 0.00 MHz (FM position). Both AM and FM verniers should be fully CCW.

6.4 Monitor AM/FM SYNC OUT with the oscilloscope. Adjust AM/FM RATE to 50 kHz and verify the sync output is a square wave, 0 to +4 volts.

6.5 Turn the AM switch to the SINE setting and turn the AM vernier fully CW.

6.6 Turn the FM switch to the SINE setting and turn the FM vernier fully CCW.

6.7 Monitor the AM output (A105, pin 10) with the oscilloscope. Adjust R93 (A105) for a 50 kHz sine wave at 2 Vpp.

6.8 Adjust the "MCAL" pot on the A5 board for a modulation meter reading of 99.0% (AM position).

6.9 Turn the FM vernier fully CW; verify a modulation meter reading of >5 MHz (FM position).

6.10 Adjust the AM vernier for a modulation meter reading of 50.0% (AM position); verify that the AM output (A105 pin 10) is at 1 Vpp.

6.11 Adjust the FM vernier for a modulation meter reading of 2.50 MHz (FM position); verify that the FM output (A105 pin 9) is at 1 Vpp.

6.12 Turn the AM switch to the SQUARE setting; adjust R72 (A105) to read an AM output (A105 pin 10) at 50 kHz (square wave), 1 Vpp. Verify a modulation meter reading of 50.0% (AM position).

6.13 Without permitting the AM vernier to move, turn the AM switch back to the SINE setting and verify that the modulation meter reading is still 50.0% (AM position).

6.14 Without permitting the AM vernier to move, turn the AM switch to 1 kHz SQUARE; adjust R80 (A105) for a modulation meter reading of 50.0% (AM position). AM output (A105 pin 10) should be at 1 Vpp.

6.15 Monitor the AM output (A105 pin 10) with the oscilloscope. Adjust R64 (A105) for a duty cycle of 50%. Adjust R68 (A105) for a frequency of 1.000 kHz. Repeat as necessary.

6.16 Without permitting the AM vernier to move, turn the AM switch to the EXT setting. Turn AM vernier fully CW. Apply a 10 kHz sine wave at 2.3 Vpp at the AM external input connector. Verify a modulation meter reading of 50.0%, $\pm$ .9% (AM position) and that the AM output (A105 pin 10) is a 10 kHz sine wave at 1 Vpp.

6.17 Turn the AM switch OFF, vernier CCW. Set AM/FM rate to 50 kHz.

6.18 Turn the FM switch to the SINE setting, and adjust the FM vernier for a modulation meter reading of 2.50 MHz (FM).

6.19 Without permitting the FM vernier to move, turn the FM switch to the TRIANGLE setting (AM/FM rate still at 50 kHz). Adjust R65 (A105) for a modulation meter reading of 2.50 MHz (FM position). Verify that the FM output (A105 pin 9) is a 50 kHz triangle wave at 1 Vpp.

6.20 Without permitting the FM vernier to move, turn the FM switch to the 1 kHz TRIANGLE setting. Adjust R61 (A105) for a modualtion meter reading of 2.50 MHz (FM position). Verify that the FM output (A105 pin 9) is a 1.000 kHz triangle wave at 1 Vpp.

6.21 Set UUT to EXT FM, with FM vernier fully CW. Apply a 10 kHz sine wave at 2 Vpp (as measured into 50 ohms) at the FM external input connector. Verify a modulation meter reading of 2.5 MHz $\pm$ .1 MHz (FM position) and that the FM output (A105 pin 9) is a 10 kHz sine wave at 1 Vpp. Turn the FM vernier fully CW; verify a modulation meter reading of 5 MHz $\pm$ .1 MHz (FM position).

7.0 External Pulse Modulation

7.1 Select EX PUL mode; apply a 10 kHz square wave (TTL levels) at the pulse EXT IN connector.

7.2 Monitor VIDEO OUT with the oscilloscope. Verify that the output is a 10 kHz square wave with levels of zero and +1.1 V (measured into 50 ohms).

7.3 Select EX TRIG mode. Turn the WIDTH switch to 10 us - .1 ms, with the vernier midrange. Verify that the output frequency is 10 kHz, and adjust the pulse width to 20 us by means of the WIDTH vernier.

8.0 Remote AM and FM

8.1 Attach UUT to an instrument controller via the IEEE-488 interface bus. Set UUT device address to 6.

8.2 Initialize UUT by sending the following command:

OUTPUT 706 "FAxxxx,LEVEL0" (where "xxxx" represents any valid frequency).

8.3 Monitor the AM output (A105, pin 10) with the oscilloscope.

OUTPUT 706 "AM SINE"
OUTPUT 706 "PANEL AM" (enables AM vernier)

Set the AM vernier to 30%, as measured by the internal modulation meter (AM position). Set the AM/FM vernier to 50 kHz, as measured by the oscilloscope.

8.4 OUTPUT 706 "PRESET AM"

Adjust R84 (A105) for a modulation meter reading of 50%. Verify a 50 kHz sine wave at 1 Vpp (A105 pin 10).

8.5 OUTPUT 706 "AM SQR"

Verify a modulation meter reading of 49-51%, and a 50 kHz square wave at 1 Vpp (A105 pin 10).

8.6 OUTPUT 706 "AM FIXED"

Verify a modulation meter reading of 49-51%, and a 1 kHz square wave at 1 Vpp (A105 pin 10).

8.7 OUTPUT 706 "AM EXT"

Apply a 10 kHz sine wave (2 Vpp) at the AM external input connector. Verify a modulation meter reading of 49-51%, and a 10 kHz sine wave at 1 Vpp (A105 pin 10).

8.8 OUTPUT 706 "AM OFF"

Verify that the modulation meter reading and the modulation waveform (A105 pin 10) drop to zero. Monitor the FM output (A105 pin 9) with the oscilloscope.

8.9 OUTPUT 706 "FM SINE"
OUTPUT 706 "PANEL FM" (enables FM vernier)

Adjust the FM vernier for a modulation meter reading of 1 MHz (FM position). Verify a 50 kHz sine wave at 1 Vpp (A105 pin 9).

8.10 OUTPUT 706 "PRESET FM"

Adjust R81 (A105) for a modulation meter reading of 2.50 MHz. Verify a 50 kHz sine wave at 1 Vpp (A105 pin 9).

8.11 OUTPUT 706 "FM TRI"

Verify a modulation meter reading of 2.45 to 2.55 MHz. Verify a 50 kHz triangular wave at 1 Vpp (A105 pin 9).

8.12 OUTPUT 706 "FM FIXED"

Verify a modulation meter reading of 2.45 to 2.55 MHz. Verify a 1 kHz triangular wave at 1 Vpp (A105 pin 9).

8.13 OUTPUT 706 "FM EXT"

Apply a 10 kHz sine wave (2 Vpp) at the FM external input connector. Verify a modulation meter reading of 2.45 to 2.55 MHz. Verify a 10 kHz sine wave at 1 Vpp (A105 pin 9).

8.14 OUTPUT 706 "FM OFF"

Verify that the modulation meter reading and the modulation waveform (A105 pin 9) both drop to zero.

9.0 Remote Pulse Modulation

9.1 Monitor pulse VIDEO OUT with the oscilloscope.

9.2 Send the following commands via the remote interface:

```
OUTPUT 706 "PULSE INT A" (selects 10 Hz - 100 Hz rate range)
OUTPUT 706 "DELAY G" (selects 10 ms - .1 s delay range)
OUTPUT 706 "WIDTH F" (selects 10 ms - .1 s width range)
OUTPUT 706 "PANEL RATE" (enables pulse rate vernier)
OUTPUT 706 "PANEL DELAY" (enables pulse delay vernier)
OUTPUT 706 "PANEL WIDTH" (enables pulse width vernier)
```

9.3 Turn the pulse WIDTH and RATE verniers across their ranges to verify that the pulses on VIDEO OUT vary correctly in rate and width. Using both pulse SYNC OUT and pulse VIDEO OUT, turn the

DELAY vernier across its range to verify that the pulse delay varies correctly. Repeat for the following settings:

9.4
```
OUTPUT 706 "PULSE INT A" (10 Hz - 100 Hz range)
OUTPUT 706 "DELAY F" (1 ms - 10 ms range)
OUTPUT 706 "WIDTH F" (10 ms - .1 s range)
```

9.5
```
OUTPUT 706 "PULSE INT B" (100 Hz - 1 kHz range)
OUTPUT 706 "DELAY E" (100 us - 1 ms range)
OUTPUT 706 "WIDTH E" (1 ms - 10 ms range)
```

9.6
```
OUTPUT 706 "PULSE INT C" (1 kHz - 10 kHz range)
OUTPUT 706 "DELAY D" (10 us - 100 us range)
OUTPUT 706 "WIDTH D" (100 us - 1 ms range)
```

9.7
```
OUTPUT 706 "PULSE INT D" (10 kHz - 100 kHz range)
OUTPUT 706 "DELAY C" (1 us - 10 us range)
OUTPUT 706 "WIDTH C" (10 us - 100 us range)
```

9.8
```
OUTPUT 706 "PULSE INT D" (10 kHz - 100 kHz range)
OUTPUT 706 "DELAY B" (100 ns - 1 us range)
OUTPUT 706 "WIDTH B" (1 us - 10 us range)
```

9.9
```
OUTPUT 706 "PULSE INT E" (100 kHz - 1 MHz range)
OUTPUT 706 "DELAY A" (10 ns - 100 ns range)
OUTPUT 706 "WIDTH A" (100 ns - 1 us range)
```

9.10 Apply 10 kHz square wave to PULSE EXT IN. Send the following command:

```
OUTPUT 706 "PULSE EXT"
```

Verify 10 kHz square wave output at VIDEO OUT. Send the following commands:

```
OUTPUT 706 "PULSE TRIG"
OUTPUT 706 "WIDTH C"
OUTPUT 706 "PANEL WIDTH"
```

Vary the pulse WIDTH vernier, and verify that the pulse width as monitored on VIDEO OUT varies across a range of 10 us - 100 us, and that the pulse repetition rate is 10 kHz.

9.11 Send the following commands:

OUTPUT 706 "PULSE OFF"

Verify that pulse VIDEO OUT is +1.1 volts DC, and that pulse SYNC OUT is at zero volts.

9.12 Send the following commands:

OUTPUT 706 "PULSE INT D" (selects 10 - 100 kHz rate range)
OUTPUT 706 "DELAY B" (selects 100 ns - 1 us delay range)
OUTPUT 706 "WIDTH C" (selects 10 us - 100 us width range)
OUTPUT 706 "PRESET RATE" (rate vernier disabled)
OUTPUT 706 "PRESET DELAY" (delay vernier disabled)
OUTPUT 706 "PRESET WIDTH" (width vernier disabled)

9.13 Adjust the preset rate pot (R52, A105) for a pulse rate of 10 kHz. Adjust the preset delay pot (R38, A105) for a pulse delay of 1 us. Adjust the preset width pot (R35, A105) for a pulse width of 20 us.

NOTE: The preset values shown above are set prior to shipment from the factory; the user has the option of changing them.

10.0 Amplitude Modulation Performance

10.1 Connect the UUT's RF OUT to the spectrum analyzer. Connect the 10 MHz IF output from the spectrum analyzer to the input of the external modulation meter. Connect the AF output of the external modulation meter to the input of the distortion analyzer.

10.2 Set the UUT to an output frequency in the middle of its range, at +5 dBm with all modulation off. Center the output signal on the spectrum analyzer.

10.3 Monitor Test Point 2 on the A5 board with the oscilloscope, and adjust the "Zero" pot on that board for a reading of zero volts DC.

10.4 Monitor AM/FM SYNC OUT with the oscilloscope. Turn the AM switch to the internal SINE mode. Set the AM/FM RATE switch and vernier to read 1 kHz on the oscilloscope. Adjust the AM vernier for an internal modulation meter reading of 50% (AM position).

10.5 Set analyzer to "zero span" (time domain), linear vertical display, internal trigger mode. Adjust the "AM" pot on the A5 board for an external modulation meter reading of 50%.

10.6 Adjust the AM vernier for an internal modulation meter reading of 20%, and verify an external modulation meter reading of 10-30%.

10.7 Adjust the AM vernier for an internal modulation meter reading of 80%, and verify an external modulation meter reading of 70-90%.

NOTE: If there is an unacceptable error at the 20% or the 80% modulation setting, readjust the 50% point (see step 12.4 above) to compensate.

10.8 Adjust the AM vernier for an internal modulation meter reading of 82%. Verify a distortion meter reading of <10%.

10.9 Attach a detector to the UUT's RF OUT connector. Monitor the detector's signal with the oscilloscope (terminate the detector into a 50 ohm load). Set the scope to 5 mV/div.

10.10 RF output at +5, AM at 1 kHz SINE. Adjust the AM vernier to see a waveform 6 divisions high on the scope (for that setting the internal modulation meter reading should be roughly 35%).

10.11 Check the AM frequency response: vary AM RATE across each range, and verify that the amplitude of the detector output waveform is between 4 and 8 divisions at all AM rates.

11.0 Frequency Modulation Performance

11.1 In order to calibrate and test the frequency modulation circuits, a special test fixture must be assembled. The recommended FM test fixture includes an RF splitter, two delay lines of unequal length, and an RF mixer. The RF output of the UUT is divided by the splitter into two signals, unequally delayed. The required differential delay can be obtained by using two coaxial cables of, for example, 5 and 10 inches in length. The outputs of these delay lines are furnished to the two inputs of the RF mixer. For certain frequencies which may be identified by experiment, the mixer will produce a DC voltage near zero. The number of "null" frequencies can be increased by making the delay lines longer in absolute terms or by increasing the ratio between their lengths. If the output becomes frequency modulated, the mixer output voltage will change, and the voltage variation will be proportional to FM deviation. The polarity of the voltage change may be either directly or inversely related to the direction of frequency deviation. When voltage levels have been established for different frequencies, the mixer output can be monitored on an oscilloscope to provide a continuous display of FM deviation.

11.2 Connect the FM test fixture to the RF OUT connector of the UUT. Monitor the mixer output with the oscilloscope (5 mV/div). Set the UUT to a null frequency (that is, at a frequency for which the mixer output voltage is zero); +5 dBm out, no modulation.

11.3 Establish the voltages at 5 MHz above and 5 MHz below the null frequency. Adjust the oscilloscope gain and the UUT output power level (near +5 dBm) in order to place the null point at the center of the screen and the 5 MHz deviation points at 3 divisions above and 3 divisions below the null point.

11.4 Set the UUT to the FM internal SINE mode. Adjust the FM vernier for a modulation meter reading of 5 MHz deviation (FM position).

11.5 Adjust the "CAL" pot on the A6 PC board in order to align the peaks of the modulated mixer output with the 5 MHz deviation points (6 divisions, peak to peak).

11.6 Verify that peak to peak deviation is less than 8 divisions, and greater than 4 divisions, at all FM rates up to 1 MHz (check each range).

11.7 Verify that the appropriate waveforms are visible in the other FM modes: 1 kHz TRIANGLE, variable TRIANGLE, and EXT (with a signal from the function generator applied to the FM input).

REQUIRED TEST EQUIPMENT

0.1 Frequency counter covering output frequency range of Series 600; time base accuracy better than 1 part in 10E9; IEEE-488 interface.

0.2 Computer/controller: any unit equipped with IEEE-488 interface, such as HP9825, HP85, PET 2001.

0.3 Power meter/sensor: HP436A with 8485A.

0.4 Spectrum analyzer: HP8566 or equivalent, with external mixers as required.

0.5 Oscilloscope: Tektronix 2465 or equivalent.

0.6 Detector: Wiltron 70S50B or equivalent.

0.7 50 ohm termination: Tektronix 011-0049-01 or equivalent.

0.8 Pulse generator: Wavetek 802 or equivalent.

0.9 Low distortion sine wave generator: Wavetek 182A or equivalent.

0.10 FM test fixture (see section 12.11 this calibration procedure).

0.11 Distortion analyzer: HP 339A or equivalent.

0.12 Modulation meter: Wavetek 4101 or equivalent.

Refer to the test data sheet at the end of this section for specifications not cited in the test procedure.

Record values as required on the test data sheet.

1.0 FREQUENCY RANGE

1.1 Allow UUT to warm up (power on) for at least 20 minutes. 1 hour for units with Option 06.

Connect RF output to frequency counter. Run UUT self-test routine in 100 MHz steps (set frequency switches to 90100.000) and monitor counter to verify frequency accuracy.

2.0 MAXIMUM OUTPUT AMPLITUDE

2.1 Connect RF output to power meter. Run UUT self-test in 50 MHz steps (90050.000) at +10 dBm, and monitor power meter to verify power within specification across the frequency range of UUT.

3.0 OUTPUT POWER ACCURACY

3.1 Perform the UUT self-test as in step 2.1 above, at 0 dBm and -4 dBm; power accuracy should be $\pm$ 2 dBm and flatness should be $\pm$ 1 dB.

4.0 FREQUENCY ACCURACY AND RESOLUTION

4.1 Check each frequency digit from 0 to 9 (as applicable) for correct UUT display and counter reading.

5.0 SPECTRAL PURITY/STEP ATTENUATOR

5.1 Perform spectral purity test as required by Test Data Sheet.

5.2 Perform On/Off test as follows:

Set HP-8566:	Set UUT:
Span = 200 kHz	Pulse Rate = 50 Hz
Center & Top Ref Level	Pulse Width = 40 msec
Span = 0 Hz	Pulse Delay = off
VBW = 300 Hz	
Trigger = Video	

5.3 Perform 10 dB step attenuator test as follows:

Set HP-8566	Set UUT:
Span = 50 kHz	RF level = 0 dB
Center & Top Ref Level	Frequency = max
	Modulation = off

Decrement RF level in 10 dB steps, and verify level accuracy $\pm$ 2 dBm. At -60 dBm change HP-8566 span to 200 Hz and step the reference level down five times (to about -50 dBm). Continue the test to -110 dBm. If more range is needed, set HP 8566 attenuator to 0 dB.

6.0 AM FUNCTIONS

Set UUT:
Pulse off Frequency -- any
FM -- off Level -- +5
AM -- sine, (vernier 30%/AM; reading may fluctuate at rates <100 Hz)

6.1 AM/FM 'SYNC OUT' to scope (2 V/div, DC); scope Ch 2 output to counter. Verify frequency range, duty cycle 50%, ± 5%, TTL levels (<.5V and >3V).

6.2 AM/FM RATE (Hz)	CW	CCW
10-100	> 100 Hz	< 10 Hz
100-1k	> 1 k	< 100
1k-10k	> 10 k	< 1 k
10 k-100 k	> 100 k	< 10 k

6.3 Attach detector to RF output, scope detectors output, 5m V/div. 50ohms. Set AM/FM rate to approx. 5 kHz. Verify sine wave on scope.

6.4 Set AM switch to square, verify square wave on detector's output and a mod meter reading of 30% ± 10% (AM%).

6.5 Set AM switch to square 1 kHz fixed verify 1 kHz square wave on dectectors output.

6.6 Set AM venier to 50% on mod meter (AM%). Set AM switch to external Connect AM/FM "sync out" to AM "ext in". Verify 20% to 40% on the modulation meter (AM%).

7.0 FM FUNCTIONS

Set UUT:
Pulse -- off Level -- +5
AM -- off AM/FM Rate -- 5 kHz
FM -- sine, max (vernier CW)

7.1 Attach FM fixture to RF out, use one of the frequencys listed on FM test fixture. Scope FM fixture output 5mV/div. A.C. Verify sine wave and a mod meter reading of > 5.0 MHz (FM MHz).

7.2 Set FM switch to triangle. Verify triangle wave on FM fixtures output.

7.3 Set FM switch to triangle fixed 1 kHz. Verify 1 kHz triangle wave on fixtures output.

7.4 Set FM vernier to 5 MHz on mod meter (FM MHz). Set FM switches to external. Connect AM/FM 'sync out' to FM 'ext in'. Verify 0.30 ± .10 on modulation meter (FM MHz).

8.0 PULSE MODULATION FUNCTIONS

8.1 Connect PULSE 'VIDEO OUT' to oscilloscope channel 2 (50 ohms, 500 mV/div). Connect PULSE 'SYNC OUT' to oscilloscope channel 1 (50 ohms, 500 mV/div). Trigger scope on CH1, display CH2. Connect CH2 output to frequency counter. Set pulse delay to minimum. Verify pulse rate in the following settings:

SET RATE, VERNIER	SET WIDTH, VERNIER	VERIFY RATE
10/100 CCW	10 ms/.1 s center	<10 Hz
10/100 CW	1 ms/10 ms center	>100 Hz
100/1K CCW	as above	<100 Hz
100/1K CW	.1 ms/1 ms center	>1 kHz
1K/10K CCW	as above	<1 kHz
1K/10K CW	10 us/.1 ms center	>10 kHz
10K/100K CCW	as above	<10 kHz
10K/100K CW	1 us/10 us center	>100 kHz
100K/1M CCW	as above	<100 kHz
100K/1M CW	.1 us/1 us center	>1 MHz

8.2 With pulse delay at minimum, verify pulse width in the following settings:

SET RATE, VERNIER	SET WIDTH, VERNIER	VERIFY WIDTH
10/100 CCW	10 ms/.1 s CCW	<10 ms
as above	10 ms/.1 s CW (slowly)	>100 ms

SET RATE, VERNIER	SET WIDTH, VERNIER	VERIFY WIDTH
10/100 center	1 ms/10 ms CW	>10 ms
100/1K center	1 ms/10 ms CCW	<1 ms
as above	.1 ms/1 ms CW	>1 ms
1K/10K center	.1 ms/1 ms CCW	<.1 ms
as above	10 us/.1 ms CW	>.1 ms
10K/100K center	10 us/.1 ms CCW	<10 us
as above	1 us/10 us CW	>10 us
100K/1M center	1 us/10 us CCW	<1 us
as above	.1 us/1 us CW	>1 us
as above	.1 us/1 ms CCW	<100 ns

8.3 Verify pulse delay in the following settings:

SET RATE, VERNIER	SET DELAY, VERNIER	SET WIDTH, VERNIER	VERIFY DELAY
10/100 CCW	10 ms/.1 s CCW	10 ms/.1 s CCW	<10 ms
as above	10 ms/.1 s CW (slowly)	as above	>100 ms
as above	1 ms/10 ms CW	as above	>10 ms
100/1K center	1 ms/10 ms CCW	1 ms/10 ms CCW	<1 ms
as above	.1 ms/1 ms CW	as above	>1 ms

1K/10K center	.1 ms/1ms CCW	.1 ms/1 ms CCW	<.1 ms
as above	10 us/.1 ms CW	as above	>.1 ms
10K/100K center	10 us/.1 ms CCW	10 us/.1 ms CCW	<10 us
as above	1 us/10 us CW	as above	>10 us
100K/1M center	1 us/10 us CCW	1 us/10 us CCW	<1 us
as above	.1 us/1 us CW	.1 us/1 us CCW	>1 us
as above	.1 us/1 us CCW	as above	<.1 us

SET RATE, VERNIER	SET DELAY, VERNIER	SET WIDTH VERNIER	VERIFY DELAY	
as above	10 ns/.1 us CW	as above	>100 ns	
as above	10 ns/.1 us CCW	as above	<10 ns	(Display CH1 & CH2; measure between rising edges at 50% points.)

8.4 Video Out vs RF Out

Set RF level to +5dBm. Using two coaxial cables of equal length, connect a level detector between UUT 'RF OUT' and channel 1 of the scope (50 ohms, 10 mV/div), and connect UUT 'VIDEO OUT' to channel 2 of the scope (50 ohms, 500 mV/div). Display CH1 and CH2; trigger scope on CH2 (+slope). Adjust CH1 volts/div vernier for waveforms of equal amplitude on both channels. Verify rising edges at 50% points are no more than 10 ns apart. (Note: The detector's negative output inverts its rising edge.)

8.5 Ext Trigger

Set UUT:
AM -- ext
AM/FM Rate -- 10K/100K, vernier CCW
AM/FM Sync Out -- connect to pulse ext in
Pulse Rate -- ext trig

Delay -- off
Width -- 10 us/.1 ms, vernier CCW

Connect scope channel 2 to PULSE 'VIDEO OUT' (50 ohms, 500 mV/div). Trigger scope on CH2, and display CH2. Adjust pulse width to about 40 us. Verify a modulation rate of 8 kHz ± 2 kHz.

8.6 Ext Pulse

Set pulse rate to ex pul. Verify a 50% duty cycle, ± 10%. Verify a modulation rate of 8 kHz, ± 2 kHz.

9.0 REMOTE MODULATION

Attach UUT to instrument controller via the IEEE-488 interface bus. Set UUT device address to 6.

Initialize UUT by sending the following command:

OUTPUT 706 "FAxxxx,LEVELO" (where "xxxx" represents any valid frequency).

9.1 Send the following commands and verify appropriate AM functions:

OUTPUT 706 "AM SINE" (internal AM, variable-rate sine)
OUTPUT 706 "PANEL AM" (front panel AM rate vernier activated)
OUTPUT 706 "PRESET AM" (preset AM rate pot activated)
OUTPUT 706 "AM SQR" (internal AM, variable-rate square wave)
OUTPUT 706 "AM FIXED" (internal AM, fixed 1 kHz square wave)
OUTPUT 706 "AM EXT" (external AM)
OUTPUT 706 "AM OFF" (AM deactivated)

9.2 Send the following commands and verify appropriate FM functions:

OUTPUT 706 "FM SINE" (internal FM, variable-rate sine)
OUTPUT 706 "PANEL FM" (front panel FM rate vernier activated)
OUTPUT 706 "PRESET FM" (preset FM rate pot activated)
OUTPUT 706 "FM TRI" (internal FM, variable-rate triangle wave)
OUTPUT 706 "FM FIXED" (internal FM, fixed 1 kHz triangle wave)
OUTPUT 706 "FM EXT" (external FM)
OUTPUT 706 "FM OFF" (FM deactivated)

9.3 Send the following commands and verify appropriate Pulse Modulation functions:

OUTPUT 706 "PULSE INT A" (10 Hz-100 Hz rate range selected)
OUTPUT 706 "DELAY G" (10 ms - .1 s delay range selected)
OUTPUT 706 "WIDTH F" (10 ms - .1 s width range selected)
OUTPUT 706 "PANEL RATE" (pulse rate vernier enabled)
OUTPUT 706 "PANEL DELAY" (pulse delay vernier enabled)
OUTPUT 706 "PANEL WIDTH" (pulse width vernier enabled)

9.3.1 Rate, Width and Delay ranges:

OUTPUT 706 "PULSE INT A" (10 Hz - 100 Hz)
OUTPUT 706 "DELAY F" (1 ms - 10 ms)
OUTPUT 706 "WIDTH F" (10 ms - .1 s)

OUTPUT 706 "PULSE INT B" (100 Hz - 1 kHz)
OUTPUT 706 "DELAY E" (100 us - 1 ms range)
OUTPUT 706 "WIDTH E" (1 ms - 10 ms range)

OUTPUT 706 "PULSE INT C" (1 kHz - 10 kHz)
OUTPUT 706 "DELAY D" (10 us - 100 us)
OUTPUT 706 "WIDTH D" (100 us - 1 ms)

OUTPUT 706 "PULSE INT D" (10 kHz - 100 kHz)
OUTPUT 706 "DELAY C" (1 us - 10 us)
OUTPUT 706 "WIDTH C" (10 us - 100 us)

OUTPUT 706 "PULSE INT D" (10 kHz - 100 kHz)
OUTPUT 706 "DELAY B" (100 ns - 1 us)
OUTPUT 706 "WIDTH B" (1 us - 10 us)

OUTPUT 706 "PULSE INT E" (100 kHz - 1 MHz)
OUTPUT 706 "DELAY A" (10 ns - 100 ns)
OUTPUT 706 "WIDTH A" (100 ns - 1 us)

9.3.2 Send the following commands and verify appropriate Pulse functions:

OUTPUT 706 "PULSE EXT" (external pulse mode)
OUTPUT 706 "PULSE TRIG" (external trigger mode)
OUTPUT 706 "PRESET RATE" (preset pulse rate pot activated)
OUTPUT 706 "PRESET DELAY" (preset pulse delay pot activated)
OUTPUT 706 "PRESET WIDTH" (preset pulse width pot activated)
OUTPUT 706 "PULSE OFF" (pulse modulation deactivated)

10.0 PULSE SHAPE

10.1 Check 50 us pulse width and 500 ns pulse width for each frequency shown on the test data sheet, as follows.

10.2 Set UUT:
RF Out -- +5 dBm
Pulse Rate -- 1K/10K, vernier CW
Pulse Delay -- off
Pulse Width -- 10 us/.1 ms, vernier centered

10.3 Adjust RF level and scope to get 5 divisions and centered, 10% and 90% are at +2 and -2 divisions. Verify overshoot and undershoot are <2 dBc.

10.4 Set pulse rate to off. Verify CW level equals the pulse level, $\pm$ 1dB.

10.5 Set pulse rate to 100K/1M, vernier CW. Set pulse width to 100 ns/1 us, vernier centered. Verify rise time and fall time are within specification and record values. Adjust RF level as required.

10.6 Repeat 10.2 through 10.5 for each frequency shown on the test data sheet.

11.0 MISCELLANEOUS FUNCTIONS

11.1 Check 'INT CLK 10 MHz' with scope (2 Vpp into 50 ohms).

11.2 Connect 'INT CLK OUT' to 'EXT CLK IN'; verify UUT unlocks.

11.3 EXTERNAL ALC

11.3.1 Set EXT ALC to enable position. Verify level display shows "-.----", UUT unleveled.

11.3.2 Connect 18 GHz directional coupler/detector to UUT RF Out. Connect detector output to EXT ALC input. Connect power meter to coupler RF output.

11.3.3 Adjust RF level switches to read +4 dBm on display. Adjust EXT ALC GAIN to read +4 dBm on power meter.

11.3.4 Set RF level switches to read -4 dBm on display. Adjust EXT ALC OFFSET to read -4 dBm on power meter.

11.3.5 Repeat 11.3.3 and 11.3.4 as required.

11.4 LEVEL CHECK

11.4.1 Connect power meter to UUT RF Out. Set UUT RF Level switches to 0.0 dBm. Increase level setting in .1 dB steps, to +0.9 dBm; verify steps on power meter, $\pm$ 0.1 dB.

11.4.2 Increase level setting in 1 dB steps, to 9 dBm; verify steps on power meter, $\pm$ 0.5 dB.

12.0 AM Depth and Distortion; FM Deviation

12.1 Connect the UUT's RF OUT to the spectrum analyzer. Connect the 10 MHz IF output from the spectrum analyzer to the input of the external modulation meter. Connect the AF output of the external modulation meter to the input of the distortion analyzer.

12.2 Set the UUT to an output frequency listed in the test data sheet, at +3 dBm, with all modulation off. Center the output signal on the spectrum analyzer.

12.3 Monitor AM/FM SYNC OUT (the output is a square wave) with the oscilloscope. Turn the AM switch to the internal SINE mode. Set the AM/FM RATE switch and vernier to read 1 kHz on the oscilloscope.

12.4 Set analyzer to "zero span" (time domain), linear vertical display, internal trigger mode. Adjust the AM vernier for an internal modulation meter reading of 80%. Verify an external modulation meter reading of 70-90%.

12.5 Adjust the AM vernier for an internal modulation meter reading of 20%, and verify an external modulation meter reading of 10-30%.

12.6 Adjust the AM vernier for an internal modulation meter reading of 50%, and verify an external modulation meter reading of 40-60%.

12.7 Verify a distortion meter reading within specification. Record in table on data sheet. Repeat 12.2 - 12.7 for other frequencys in table.

12.8 Attach a detector to the UUT's RF OUT connector. Monitor the detector's signal with the oscilloscope (terminate the detector into a 50 ohm load). Set the scope to 5 mV/div.

12.9 RF output at +5, AM at 1 kHz SINE. Adjust the AM vernier to see a waveform 6 divisions high on the scope (for that setting the internal modulation meter reading should be roughly 35%).

12.10 Check the AM frequency response: vary AM RATE across the 10 Hz - 50 kHz range, and verify that the amplitude of the detector output waveform is between 4 and 8 divisions throughout this range.

12.11 (Frequency Modulation Performance) In order to calibrate and test the frequency modulation circuits, a special test fixture must be assembled. The recommended FM test fixture includes an RF splitter, two delay lines of unequal length, and an RF mixer. The RF output of the UUT is divided by the splitter into two signals, unequally delayed. The required differential delay can be obtained by using two coaxial cables of, for example, 5 and 10 inches in length. The outputs of these delay lines are furnished to the two inputs of the RF mixer. For certain frequencies which may be identified by experiment, the mixer will produce a DC voltage near zero. The number of "null" frequencies can be increased by making the delay lines longer in absolute terms or by increasing the ratio between their lengths. If the output becomes frequency modulated, the mixer output voltage will change, and the voltage variation will be proportional to FM deviation. The polarity of the voltage change may be either directly or inversely related to the direction of frequency deviation. When voltage levels have been established for different frequencies, the mixer output can be monitored on an oscilloscope to provide a continuous display of FM deviation.

12.12 Connect the FM test fixture to the RF OUT connector of the UUT. Monitor the mixer output with the oscilloscope (5 mV/div). Set the

UUT to a null frequency (that is, at a frequency for which the mixer output voltage is zero -- see list of frequencies); +5 dBm out, no modulation.

12.13 Establish the voltages at 5 MHz above and 5 MHz below the null frequency. Adjust the oscilloscope gain and the UUT output power level (near +5 dBm) in order to place the null point at the center of the screen and the 5 MHz deviation points at 3 divisions above and 3 divisions below the null point.

12.14 Set the UUT to the FM internal SINE mode. Adjust the FM vernier for a modulation meter reading of 5 MHz deviation (FM position).

12.15 Verify that peak to peak deviation is less than 8 divisions, and greater than 4 divisions, at all FM rates from 10 Hz to 1 MHz (external mode). Check each frequency range.

12.16 Verify that the appropriate waveforms are visible in the other FM modes: 1 kHz TRIANGLE, variable TRIANGLE, and EXT (with a signal from the function generator applied to the FM input).

TEST DATA SHEET -- MODEL 600

Quality Assurance _____ Tested By _____

Date _____ S/N _____ Model _____

[X]

1. Frequency Range

[ ] 1.1 UUT is locked and leveled throughout its frequency range at +10dBm

2. Maximum Output Amplitude

[ ] 2.1 Maximum power exceeds +10dBm, $\pm$ 2dBm, throughout UUT's frequency range

3. Output Power Accuracy

[ ] 3.1 UUT meets the required power accuracy throughout its frequency range, accuracy $\pm$ 2dBm and flatness $\pm$ 1dB.

4. Frequency Accuracy ($\pm$ $1x10^{-6}$) and Resolution

[ ] 4.1 1 MHz digit function

[ ] 4.2 10 MHz digit function

[ ] 4.3 100 MHz digit function

[ ] 4.4 1 GHz digit function

[ ] 4.5 10 GHz digit function

5. Spectral Purity/Step Attenuator

5.1 &5.2 Record readings for all of the following frequencies that are available in the instrument being tested (table on following page). Frequencies are in MHz. RF level setting is 0 dBm. The second harmonic for each frequency is given in brackets.

FREQUENCY	SECOND HARMONIC	SPURIOUS (SPAN: 1 GHz TO 50 kHz)	NOISE @10 kHz 1 Hz BW	LINE/FAN RELATED	ON/OFF RATIO
spec:	≤ -40 dB	≤ -55 dB	≤ -75 dB	≤ -40 dB (-45 dB Typ)	≥ 80 dB
5447.742 [10895.434]	_____	_____	_____	_____	_____
9182	n/a	_____	_____	_____	_____
12317	n/a	_____	_____	_____	_____

[ ] 5.3 10 dB Step Attenuator, accuracy ± 2dBm. Tested @ Fmin + 47 MHz

6. AM Functions

[ ] 6.1 AM/FM Sync Out (TTL levels)

[ ] 6.2 AM/FM Rate -- Variable (10-100, 100-1K, 1K-10K, 10K-100K)

[ ] 6.3 AM Sine wave, variable rate

[ ] 6.4 AM Square wave, variable rate, modulation reading >90%.

[ ] 6.5 AM Square wave, fixed 1.000 kHz

[ ] 6.6 External AM

7. FM Functions

[ ] 7.1 FM Sine wave, variable rate, modulation reading >5.0 MHz

[ ] 7.2 FM Triangle wave, variable rate

[ ] 7.3 FM Triangle wave, fixed 1.000 kHz

[ ] 7.4 External FM

8. Pulse Modulation Functions

[ ] 8.1 Internal Pulse Rate (10 Hz to 1 MHz)

[ ] 8.2 Pulse Width (100 ns to 100 ms)

[ ] 8.3 Pulse Delay (10 ns to 100 ms)

[ ] 8.4 Video Out vs. RF Out

[ ] 8.5 External Trigger

[ ] 8.6 External Pulse

9. Remote Modulation

[ ] 9.1 Remote AM

[ ] 9.2 Remote FM

[ ] 9.3 Remote Pulse Modulation

10. Pulse Shape

Record readings for all of the following frequencies that are available in the instrument being tested.

FREQUENCY	RISE TIME	FALL TIME
spec:	≤ 50 ns	≤ 50 ns
6500	_____	_____
8500	_____	_____
11500	_____	_____

11. Miscellaneous Functions

[ ] 11.1 10 MHz INT CLK Output, 2 Vpp into 50 ohms

[ ] 11.2 10 MHz EXT CLK

[ ] 11.3 External ALC

[ ] 11.4 Level check (1 dB & .1 dB increments)

12. AM Depth and Distortion; FM deviation

Record readings for all of the following frequencies that are available in the instrument being tested.

FREQUENCY	AM DEPTH (%)	AM DISTORTION
spec:	50% ± 10%	≤ 10% @ 1 kHz
6500	_____	_____
8500	_____	_____
11500	_____	_____

FM DEVIATION 5 MHz ± 3dB

[ ] 6514

[ ] 11213

MP MASTER
MA29188